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APR 8 1921

GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE WATER SUPPLY

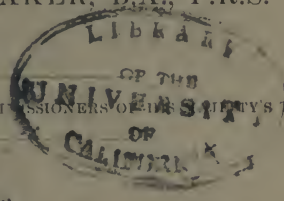
OF

NORFOLK

FROM UNDERGROUND SOURCES.

BY

WILLIAM WHITAKER, B.A., F.R.S.



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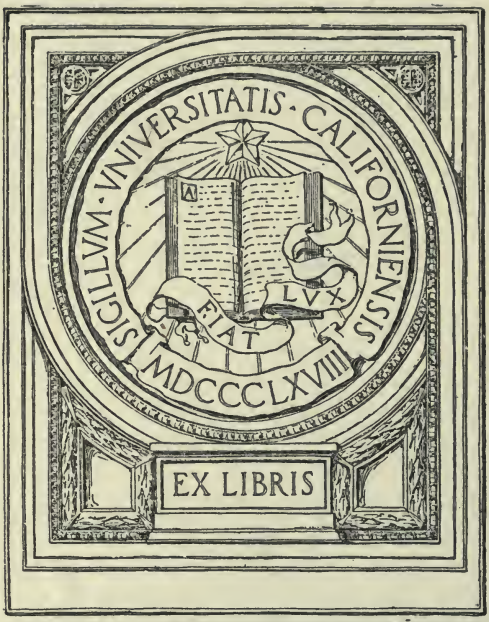
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PREFACE.

This volume is the thirteenth of the Water Supply Memoirs published by the Geological Survey, with reference especially to the south-eastern counties of England. It has been compiled by Mr. W. Whitaker, F.R.S., whose long acquaintance with the geology of the county of Norfolk and eminent services to the study of underground waters of England have rendered him specially competent for the task. The county of Norfolk from its situation, its geology, and its surface-features is in large measure dependent on springs, wells and bores for supplies of drinking-water and the information given in this Memoir shows not only the distribution and origin of these supplies but also the remarkable progress that has been made in the last fifty years in providing safe drinking-water for both the urban and the rural communities in the county.

Mr. Whitaker, as in previous Memoirs of this series, has been generously helped with information by local proprietors, occupiers, engineers, well-sinkers and others. In particular he desires to acknowledge the assistance received from Mr. Sutton, Analyst to the County of Norfolk, both from published and unpublished sources, without which it would have been difficult to deal with the subject in an adequate manner.

JOHN S. FLETT,
Director.

GEOLOGICAL SURVEY OFFICE,
28, Jermyn Street,
London, S.W.1.
18*th October*, 1920.

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THE WATER SUPPLY

OF

NORFOLK.

INTRODUCTORY.

Population.

According to the Census of 1911 the Administrative County of Norfolk contained 1,370,570 acres, and had a population of 321,748, an increase of 10,433 over that of 1901.

In Norfolk there are only two places up to the standard of a county-borough, namely the city of Norwich, with a population of 121,493, an increase of 7,571 over that of 1901, and the town of Yarmouth with a population of 55,808, an increase of 4,492.

There are only two other towns with a population of over 5,000; Lynn, with 20,205, a decrease of 83 as compared with 1901, and East Dereham with 5,729, an increase of 184.

Besides the above there are a number of small towns and large villages, and a large number of the small villages that mark an agricultural tract. The capital city, indeed, is the only place that can be looked on as a manufacturing centre, with several large works. As distributing centres the ports of Yarmouth and Lynn are notable.

Boundaries.

Norfolk is essentially one of our maritime counties. On the east it is mainly bordered by the sea, on the north wholly, and on the west to some extent. Its ports are Yarmouth, on the east, and Lynn, on the west, besides some small ones on the north. Its coast, from Hunstanton, on the north-west, to Yarmouth, is more or less studded with other seaside-resorts, of which Cromer, in the middle, is the most notable.

Its other boundaries are largely river-courses. From Yarmouth the south-eastern and southern boundary runs up the Waveney, from its mouth by the towns of Beccles and Bungay (both in Suffolk) and Harleston and Diss to its source, between South Lopham and Redgrave (in Suffolk), that source being practically the same as that of the opposing river the Little Ouse, which, flowing down the other way (westward) continues the southern boundary, by the towns of Thetford and Brandon (in Suffolk); until several miles below the last place, the county-boundary quits the stream for a very small wander in Hockwold Fens, on the north, followed by a larger one at Redmere, on the south; then returning to the stream until this joins the Ouse.

Beyond the Ouse the boundary runs westward and then north-westward, still across the Fens, to the Old Croft River, following which it runs northward to the Nene at Upwell. Then going along that river towards Wisbech, it circles round that town and continues its northerly course, firstly a little west of the Nene and lastly a little east thereof to the Wash. On the west, therefore, the boundary is in the Fenland for the most part, and the rest under the Wash. On the whole, Norfolk has a natural boundary.

Surface Levels.

For so large a county there is a notable want of high ground. Starting from a few feet below high water-mark in the marshlands of the river-estuaries, very little of the ground reaches to 300 feet above Ordnance Datum.

The small area that reaches to a height of 300 feet occurs in fourteen very small patches, in two districts. In the west, on the Chalk, mostly Drift-covered, are nine of these, and to the north of them, at Docking, a height of 290 feet is reached.

The most northerly patch is just north of the village of Harpley, then come a very small one just westward of Little Massingham and a rather larger one a little further west. Just southward is a patch, west of the village of Great Massingham, then another at the south-eastern part of Massingham Heath and beyond, with a smaller one just southward of the Heath (in the parish of West Acre?). These five run in a north and south line, and a little to the west of it is a very small patch near the western border of Massingham Heath, but in the parish of Gayton.

The other two areas are to the south-east, one being just east of the village of Little Dunham, and the other at the border of the parishes of West and East Bradenham, just northward of Bokenham Manor.

In this last a height of 311 feet is marked on the Ordnance Map, and as no other height above the 300 feet contour is marked anywhere else, we may assume that none of these small areas reach to a height of many feet above 300. The area of the whole eight is only about 2 square miles.

The other five patches of over 300 feet, also with a total area of about two square miles, are on the northern border of the county; three of them form part of the high ground overlooking the coast westward of Cromer. The longest of these stretches from Great Wood, in the parish of Aylmerton, to The Brakes, in the parish of Beeston, with a small part in the parish of Runton and a mere trace in that of Felbrigg. It is mainly in the first named parish, and the mark of a height of 320 feet seems to place Aylmerton as having the highest ground in the county.

Another area is in the parishes of East Beckham and Upper Sheringham, and a third small one in the latter.

The other two are a little further south, one in the parishes of Bodham and West Beckham (south of the latter village), with a slight incursion into Baconsthorpe, and the other in the parish of North Baningham, also with a slight digression into Baconsthorpe as well as into West Beckham.

The highest ground, therefore, is close to the northern coast, and it is singular that the whole of the ground here is composed, from

top to bottom, that is to say down to sea-level (as far as we know), of Drift, (with a small amount of Pliocene beds at the base), in other words of clays, loams, gravels and sands, materials largely of a somewhat unconsolidated character and liable to fairly rapid action from erosive agencies.

In 1883 there was a little controversy as to the highest point in Norfolk, and an appeal by G. M. Reade, to the Ordnance Survey drew the answer that "the highest point *levelled to* is 6,725 links North-east of Aylmerton church, and 331·4 feet above O.D."*

The Chalk-escarpment, usually a strongly marked topographic feature, runs north and south along the western part of the county; but it has for the most part a long gentle slope, in great contrast to the sharp slopes of the North and South Downs, of the Chilterns, etc. The highest points have been noticed above, and they are mostly with a covering of Drift.

The other escarpment of Norfolk, that of the Lower Greensand, though not reaching anything near to the height of the Chalk-escarpment, is nevertheless more marked in some favoured places, because of its sharper rise: moreover, it is emphasized by the low ground at or near its base, as it directly overlooks the flats of the Fenland or the waters of the Wash. This is particularly notable in the neighbourhood of Sandringham. In the north, however, it is largely obscured by Drift.

As a whole the dominant feature of Norfolk is the wide-spread mantle of Drift, which hides the beds below, except where deep valleys have been cut through it; and the Drift tends to an evenness of surface-levels.

Rivers.

General Remarks.

The following account of the rivers of Norfolk may serve to show their general features, their relations to one another, and their vagaries. It may perhaps lead to a more detailed study of some of them, based on the six-inch Ordnance maps. In these notes the new series of the one-inch maps has been taken as a foundation, with reference also, of course, to the geologic maps, on the old one-inch sheets; personal knowledge of many parts has naturally been useful.

Antiquaries and local observers may perhaps have something to say on questions of nomenclature; but it is fairly obvious that, in a work of this sort, some one authority must be generally accepted, and the Ordnance maps seem to be the only one available, being within reach of most people who are interested in the subject.

Notes on the various rivers have been given in the Geological Survey Memoirs on the sheets of the map which refer to Norfolk, but these, of course, are disjointed, each memoir dealing only with a particular district, whilst here we deal with the county as a whole.

Norfolk is mainly in two river-basins, on the west in that of the Ouse, a wide-spreading tract, to which many counties contribute; but the greater part in that of the Yare, which is chiefly a Norfolk

* *Geol. Mag.* dec. ii, vol. x, p. 140.

tract, with an extension into Suffolk, along the eastern half of the southern border of our county. The remainder is the drainage area of streams that find their way to the sea along our northern border, and some of which, though now independent, probably once joined the Ouse, at that distant time when the land extended several miles further northward than now.

The Ouse itself passes, in a northerly course, through Norfolk, from south of Southery, by Downham Market, the Wiggenhalls, and Lynn, to the Wash, after receiving the tributary Little Ouse, the boundary-stream. Its course is either through, or by the eastern edge of the Fenland, and it is chiefly tidal in Norfolk, the effect of the tide going up as far as Denver Sluice, and there being artificially stopped, except for which the river would be wholly tidal, as far as Norfolk is concerned.

Of the set of streams that are tributary to this river it is to be noted that they have a general westerly course, that is, one in an opposite direction to that of the general dip of the Chalk, and that though in the north the streams are short the length increases southward, until at last the westerly-flowing Little Ouse and its tributary the Thet reach half across the Chalk and Tertiary tract of the county, an unusually long course for streams flowing against the dip of these formations.

The drainage of the *Yare* and its tributaries, on the other hand, has a general easterly direction, for though the streams flow or wind about in various directions, the ultimate flow is to the eastern coast, at Yarmouth.

Basin of the Ouse.

The Little Ouse has been taken to have a conjoint origin with the opposing stream, the easterly-flowing Waveney, in Little Fen, between the Norfolk village of South Lopham and the Suffolk village of Redgrave, a place marked as Lopham Ford on the old map (50, N.W.), a name which has become well-known from the fact of two rivers starting there. But as F. J. BENNETT has said "the source of the Little Ouse is really in three brooks that unite near Bottesdale" (in Suffolk)[1], where streams from the Chalk and the Drift collect and flow northward to a point less than three quarters of a mile below the reputed origin at Little Fen. There are Chalk-springs near Bottesdale at a higher level than Little Fen.

In treating of the valley of the conjoint streams at Lopham Ford, the REV. O. FISHER made the following remarks in 1868. "The peculiarity of this valley is that it intersects the watershed at right angles, and slopes east and west to the German Ocean (wrongly so-called) and the Wash. The watershed in the valley is formed by a very low ridge of sandy ground, not more than four or five feet high, and 235 yards across. East and west of this commence wide fens, which occupy the upper end of the eastern and western portions drained by the Waveney and Little Ouse respectively. The (old) Ordnance map is deceptive in making it appear that these rivers rise together, and then separating, flow east and west. It is not so. The sandy tract just mentioned intervenes."[2]

[1] The Geology of the Country around Diss, etc., 1884, p. 1.
[2] *Geol. Mag.*, Vol. V., p. 557.

The same thing, however, is shown perhaps still more definitely, on the newer map (175). From my own recollection of a visit paid many years ago, the two streams have been artificially connected by a cut channel, and this is borne out by F. J. BENNETT'S remark (in the Diss Memoir, p. 2) that the "sandy tract is intersected by dykes, which, however, are dammed up by the road which has been carried across the valley as a 'causeway.' Its low embankment now really forms the boundary between the drainage areas of the Ouse and Waveney."

FISHER goes on to say "the valleys of these two rivers do not really commence at this watershed. The Waveney really rises in Norfolk to the north of this, and the Little Ouse in Suffolk to the south. The valleys then inosculate, and thus the appearance of one continuous valley reaching from sea to sea is produced."

From Little Fen the first three miles of the stream is in a Drift-tract, by Blo' Norton, a little below which place it enters the Chalk-district (with Drift more or less on the higher ground), and passes by the following Norfolk villages, Gasthorpe, Riddlesworth and Rushford, turning northward to the town of Thetford, beyond which it soon retakes to its westerly course, by Santon and Hockwold, where it leaves the Chalk-tract for the Fenland, through which it flows to the Ouse, at Brandon Creek, S.S.W. of Southery.

The Little Ouse has few tributaries (and only one of importance) on its right, or Norfolk side, and this is a good illustration of the general dryness of a Chalk-tract, in which water sinks in and flows underground. The first tributary (not very well shown on the one-inch Ordnance Map, 175) starts near Uphall, in the parish of North Lopham, and has a short southerly course, through Garboldisham.

The next, which joins many miles lower down, is *The Thet*, a composite stream in its upper part, that is above East Harling, where it is formed by the drainage of a large tract, chiefly of Drift but partly of Chalk, near New Buckenham and Attleborough, and far westward of those towns. The water is collected by various streams, flowing in various directions and joining up in various places, above East Harling; but to these streams no names are given on the one-inch Ordnance maps, except in the case of *The Wittle*, which, fed from Drift and Chalk near Kenninghall and Banham, joins the main stream just above East Harling.

At Snetterton what seems to be the main stream of The Thet first enters into uncovered Chalk and must receive a good deal of Chalk water by means of the stream from East Wretham, on the west. From East Harling the now combined stream takes a west-south-westerly course, by Bridgham and Brettenham, through Chalk, to the Little Ouse at Thetford, with a rough parallelism to that river, and with but a trifling tributary from West Harling.

The almost bare Chalk-tract through which the little Ouse now flows yields no tributary, except for the tiny short stream from Westing. Of the Fenland part of this and other rivers there is little to be said, the water-courses of that tract having been greatly artificialised.

The Wissey, or *Stoke River*, which is wholly a Norfolk stream, has most of its points of origin far inland. The particular branch

to which the name is given starts at East Bradenham, and is the result of the drainage of a large tract of Boulder Clay. It flows westward for a few miles by West Bradenham and Holme Hale, receiving small tributaries on either side, and then turns nearly southward, by North Pickenham (where it first touches bare Chalk) and South Pickenham, Great Cressingham (where it practically enters the Chalk-country), Hilborough, Bodney and Langford, to Buckenham Tofts Park. Then it turns westward (still in Chalk), by Ickburgh and Mundford and then west-north-westward, by Didlington and Northwold, to Stoke Ferry, where it enters the Fens and passes through them to the Ouse opposite White House Farm, or Hilgay Creek Ferry of the old map.

On the left side the first notable tributary, though unnamed on the Ordnance Map (160) seems to start at Scoulton Mere (gravel) and thence flows westward to Watton to receive the drainage of the Boulder Clay tract. Reinforced from the Chalk of Saham Toney it continues westward, mainly through Chalk, by Threxton and Little Cressingham, to the main stream at Hilborough.

A little to the south is another tributary, starting in the Drift tract around Thompson. Turning westward it flows through Thompson Water, where it enters a small Chalk-area on the southern side, to Tottington, and then, finally entering the Chalk-tract, through Stanford Water, to the main stream in Buckenham Tofts Park, where this tributary imposes its westerly course on the main stream. A little lower down, at Mundford, a little deflection of the main stream, north-westward, follows the junction of the short tributary from West Tofts.

The only other tributary on the left side is the Methwold Lode, which, starting in the Chalk eastward of the village of Methwold flows about W.N.W. through the Fen to the Wissey about two miles below Stoke Ferry, and apparently causes the main stream to revert to the westerly course which it had left for a short way.

After leaving its head-waters the Wissey has no tributary on the right side for a long way. The first one is very short, and starts N.E. of Foulden, whence it flows S.S.E. across the Common to the river south of Oxborough. The next one is near by, starting at a Chalk-spring nearly 1½ miles E.N.E. of the village of Cockley Cley, whence it flows south westward through the Chalk, by that village and Gooderstone to Oxborough, where it joins the river just below the other stream.

A compound stream rises in the Chalk at places round Beechamwell and Barton Bendish and receives some additions from the Boulder Clay near Fincham. The various waters combine between Boughton and Oxborough and the resultant stream joins the Wissey within two miles, a little above Stoke Ferry.

The result of these streams seems to be to turn the main stream eastward near Oxborough, and then southward, by Stoke Ferry.

From Downham Market to Watlington the Ouse receives but very small additions, from the tract of Boulder Clay and Lower Greensand.

The Nar is the next notable tributary, and it starts far inland, from the drainage of a Drift-tract near Mileham; but in its course, a little south of west, it at once passes to the Chalk and flows over that formation, which is more or less capped with gravel, by Litcham,

East and West Lexham, Newton Castle, South and West Acre Narford and Narborough, below which place it is canalised and beyond which it enters an inlet of the Fens, which largely hide the successive outcrops of the Gault, the Lower Greensand and the Kimeridge Clay. On reaching the main Fenland the Nar turns northward and, gradually nearing the Ouse, joins that river at Lynn.

On its left or southern side above Narborough the Nar has no notable tributary, only receiving a few short small streams from the Drift-tract of Beeston and Great Dunham, but it gets much water from Chalk-springs. To some of these is due the longer stream, mostly confined to the Fen, from Marham to Wormegay.

On the right, or northern, side there are no streams above Narford.

In the neighbourhood of East Walton various springs from the Lower Chalk give rise to short streams which join the river on either side of Narborough. Another stream starts near by, at Gaytonthorpe, and flows south-westward, by West Bilney, to the marsh south-eastward of Blackborough End.

Starting near this last, at Gayton, from the base of the Chalk, is an easterly-flowing stream, over Gault, Lower Greensand and Boulder Clay, which apparently joins the Nar at Lynn; but seems also to be linked up round that town to the Gaywood River on the northern side of the town. On the old Ordnance map (65) the name Middleton Stop Drain is given to the lower (artificial) part of this stream. In this part streams have been much artificialised.

The last tributary of the present Ouse is *The Gaywood River*, which starts at the springs from the base of the Chalk north of Gayton and thence to Grimston, the combined stream flowing eastward, by Gaywood, to the Ouse at Lynn.

Streams flowing into the Wash or into the Sea.

The *Babingley River* usually rises in the Middle Chalk about a mile above the village of Flitcham (*see* p. 37), and flows westward, near Hillington and Castle Rising, across Lower Chalk, Gault and Lower Greensand (from which it receives additions, from near West Newton) but turns northward, just before reaching the Wash, west of Wolferton.

The next stream (? *The Ingol*) rises at the base of the Chalk at Shernborne, flows eastward over the Lower Greensand, between Ingoldisthorpe and Snettisham, and then, passing through the Alluvial flat, is turned southward by the long bar of shingle, to find its way out to salt water by Wolferton Creek.

The Heacham River starts in the Middle Chalk above the village of Sedgeford; but presumably the rising-point varies, and there is a bourne-flow after times of heavy rainfall. The stream flows across Lower Chalk and Lower Greensand W.N.W. to beyond Heacham village, when it meets the shingle-bar and is turned southward to Heacham Harbour. The short stream that rises in the Chalk-valley at Ringstead Downs (? in the parish of Hunstanton) joins this just northward of Heacham.

We have finished now with the westerly flowing streams, into the Wash, all of which really belong to the Ouse system, and come to

those that flow northward to the sea. The first of these starts in the Chalk of Hunstanton Park, flows northward by the eastern side of the old village and then turns north-eastward through the marsh, to the sea northward of Holme.

Eastward of this there are no streams, except those in the strip of marsh that fringe the coast, for several miles, until we come to *The Burn*, starting from the Chalk of South Creake and flowing northward, by North Creake, Burnham Thorpe and other Burnhams, to the sea at Burnham Harbour.

On the old Ordnance map (68, N.W.) a short stream is shown from north of Warham All Saints to Wells Harbour.

The Stiffkey rises a good way inland, starting in the Drift-tract of Swanton Novers and Barney. Thence it wanders westward, still over Drift, by Croxton and Great Snoring, till its valley cuts through to Chalk a little above East Barsham, just below which the stream turns sharply north-north-eastward, by North Barsham, Houghton St. Giles, Little (or New) and Great Walsingham (the Little and Great of which names are curiously misplaced), Wighton and Warham All Saints; then taking a more easterly course, by Stiffkey, still over Chalk (with Drift on the higher ground), and then northward across the marsh to Blakeney Harbour.

The vagaries of this river seem to have nothing to do with the incoming of tributaries, but rather the reverse, the only important tributaries, which are on the right or eastern side, not having any effect in preventing the eastward tendency of the stream.

In the upper part these are merely insignificant water-courses, carrying the drainage of the Boulder Clay, when there is any. The first notable addition is a short stream, starting in the Boulder Clay tract near Hindringham, flowing W.N.W. to below Great Walsingham, and reaching the Chalk in the lower half of its course. The longest tributary starts from Boulder Clay drainage near Sharrington and Saxlingham, and has a general W.N.W. flow by Langham, below which place it receives another Boulder Clay streamlet on the south, from Bale and Field Dalling, and then cuts through to Chalk, by Binham to just below Warham All Saints.

The Glaven starts from the drainage of a large tract of Drift (Gravel and Boulder Clay) around Holt, and near Bodham, Hempstead, Edgefield, Stody, Thornage, Brinton and Gunthorpe. The various streams, from N.E., E., S. and W., join together at various places, and the combination is perfected a little below Hunworth, whence the joint stream flows northward, by Letheringsett (where it cuts through the Drift to the Chalk), Bayfield, Glandford and Wiveton to Cley, where it passes across the marshes to the shingle-bank by Blakeney Eye, which turns it sharply westward, to Blakeney Harbour. There are no tributaries in the lower part, whereas in the upper part there is no main stream.

Eastward of this there are no rivers flowing into the sea, on the northern coast, only slight drainage from the Drift, the boundary of the Yare Basin being near the coast; but at the last a short Drift stream starting near Northrepps flows E.S.E. by Gimingham to the sea at Mundesley, beyond which the south-eastern coast passes into the Basin of the Yare, its water flowing inland.

Basin of the Yare.

The Yare itself, which is tidal up to Norwich, is purely a Norfolk river, and it is only its most southerly tributary, the Waveney, that gets water from another county. It is a very composite river, and the branch to which the name is given is not the longest. At its head, moreover, this bears the name of *The Blackwater*, which starts with the drainage of the Drift at Shipdham and flows S.E. to Woodrising, where it turns eastward by Southburgh to Hardingham Railway Station, there receiving on the W.N.W. another Drift stream from eastward of Shipdham, by Whinburgh and Thuxton, the joint-stream apparently taking the name Yare. It meanders eastward, still over Drift, by Coston to Marlingford, where it cuts through the Drift to the Chalk. Continuing its generally easterly course, by Bawburgh and Colney, it makes roughly a half circle by Cringleford and Keswick round Norwich. Its tidal course is then continued eastward, but with a broad southerly bow for the greater part of its length, by Thorpe, Bramerton, Surlingham Broad, Brundall, Cantley, Reedham and Breydon Water to the northern part of Yarmouth, where it is turned southward by the bar of Blown Sand and Shingle, on which the town is built, for a distance of nearly three miles, finding its way to the sea by the Suffolk village of Gorleston.

The first tributary on the right side of the Yare starts from the drainage of the Boulder Clay around Wymondham. Although no name is given to the stream on the newer Ordnance Map (161), on the older one (66, S.W.) three of its branches are thus dignified, the one S.E. of the town being called *The Tiffey*, that to the S. *Bay's River*, and that to the S.W. *Dyke Beck*. The combined stream (to which no name is given) flows N.N.W. to Kimberley Park, where it receives a tributary from the Drift near Hingham and Hackford, which has the effect of changing its course to a north-easterly one, still in Drift, by Carleton Forehoe and Wramplingham to the Yare near Great Melton.

The next tributary joins but little lower down. It is a short stream from the Boulder Clay tract between Hethersett and Great Melton, flowing at first N.N.E. and then turning W.N.W. over Chalk to opposite Marlingford.

Then there is a short two-headed stream, from the Drift N.W. of East Carleton and from the Drift and Crag S.E. of that place, both branches partly reaching to Chalk, and the very short joint stream going north to the Yare by the parish-boundary between Cringleford and Keswick.

The Tas (*Tese* or *Taus* of the old map) comes in some two miles lower down. It starts with the drainage of the Boulder Clay near Carleton Rode, Bunwell, Tibenham and Moulton St. Michael, and has at first an easterly and then a general north-north-easterly flow by the Forncetts, where it cuts through the Boulder Clay to the Crag, reaching also to the Chalk above Newton Flotman, and then by Stoke Holy Cross and Caister Edmundus to the Yare southward of Norwich.

On its right is a tributary which starts in the Boulder Clay tract of Hardwick and flows N.N.E. across it to Hempnall, where a

shorter Boulder Clay stream joins from the east, and imposes its westerly course on the combined stream, which at once cuts through to the Crag, and then at Upper Tasburgh to the Chalk, through which it flows for the last mile of its course to Tasburgh.

A shorter stream starts apparently from the drainage of the Boulder Clay near Saxlingham Green, soon cuts through to the Crag, flows westward by Saxlingham Nethergate, and then, partly through Chalk, to Saxlingham Thorpe, not, however, where that place is marked on the old map.

Another stream starts in the Boulder Clay eastward of Saxlingham Green and flows north-westward, cutting down into the Crag above Shotesham All Saints, and below that place into the Chalk, to the church of Stoke Holy Cross. A small addition to this comes from near Blackford Hall on the N.E.

On the left side the Tas has also tributaries. On the old maps (66, S.W. and S.E.) one is marked as starting in the Boulder Clay southward of Tacolneston ; but on the new map (161) only the eastern part of this is shown, where it enters the Crag, near Hapton.

The other starts, with two branches, from the Boulder Clay near Wreningham. The combined stream soon cuts through to the Crag and then to the Chalk, in its south-easterly course, by Flordon, near which place its joins the Tas.

A very short addition to the Tas is made from Drift and Chalk southward of Swainsthorpe.

The next tributary to the right side of the Yare is short and nameless. It starts from the Crag northward of Yelverton and flows east by Hillington toward Claxton, when it turns N.E. through the marsh, joining the river east of Rockland Broad.

A little below is a still shorter tributary, from the Drift gravel and sand near Thurton, which flows in a north-easterly direction by Carleton St. Peter, where it cuts down to Crag and thence across the marsh.

The Chet seems to start in the Boulder Clay tract of Poringland. It soon takes a general easterly course, by the N.E. of Brooke, where it cuts through to Crag, by the church of Burgh Apton and Loddon, some two miles below which town it turns north-eastward to the Yare at Hardley Cross.

A short stream starts apparently in Glacial sand and gravel, southward of Norton Subcourse and Thurlton, and flows north-eastward into Norton and Thurlton Marshes.

The chief tributary on the right side of the Yare, and it is the last, is *The Waveney*, which forms the county-boundary throughout its course, starting at the same place as the other boundary-river, the Little Ouse, as noted above, p. 4. It is tidal up to the lock southward of Geldeston.

Starting in the Glacial gravel and sand, the Waveney flows through that set of beds in its easterly course to below Diss, when it reaches the Chalk for over a mile, to just beyond Scole, below which it retakes to the Drift, including the Boulder Clay, and remains therein to the end, save for places where it cuts down to the Crag Series.

Some two miles below Scole its direction changes to a nearly north-easterly one, by Brockdish, Needham, south of Harleston, Wortwell,

Earsham (where it takes a long and curious loop northward, round the Suffolk town of Bungay) and Ellingham. Then it reverts to an easterly course, by Geldeston and Gillingham, with a broad loop round the town and marshes of Beccles (in Suffolk). Passing through its wide marshes to the church of Burgh St. Peter (1½ miles east of the village) it takes a general northerly course, curving in to the west to near the Suffolk village of Fritton, and joining the Yare by Burgh Castle, also in Suffolk, only a few miles from the sea.

The Waveney has a number of tributaries on its left, or Norfolk side. The first joins very near the start of the river, and is merely a very short stream, resulting from the drainage of the Boulder Clay near North and South Lopham and flowing north to Little Fen. It is this which forms the highest water of the Waveney, and should strictly be looked on as the start of that river (*see* p. 10). The next, near by, is a similar stream, from Fersfield to Bressingham Fen.

Then there is the result of the drainage of the Boulder Clay of Shelfhanger, Winfarthing, Burston, Gissing, and Dickleburgh, the various streamlets combining until they became one south of Burston, whence the stream flows southward east of the town of Diss.

We pass now to the stream from the Boulder Clay of Tivetshall St. Margaret and St. Mary, Pulham St. Mary Magdalene and St. Mary the Virgin, which flows S.S.E. near those places and then turns eastward and east-north-eastward, cutting through to the Glacial Gravel, and at one place to Crag, by Starston, Harleston and Redenhall, and to the Waveney opposite Homersfield, in Suffolk.

A small stream from the Boulder Clay north-westward of Denton, cutting down into the Crag at that place (*not* where it is marked on the old map, 65, S.E.) continues its south-easterly course to the Waveney.

The next tributary is *The Broome Beck*, which flows over Crag from westward of Woodton in a general east-south-easterly direction, by Bedingham, Hedenham and Ditchingham to the Waveney near Broome (but not where that name is marked on the old map, 66, S.E.), receiving a slight addition from the Boulder Clay of Thwaite on the north. Judging by the geologic map, it seems possible that this stream may once have continued eastward, through the Alluvium on the northern side of Ellingham Island, and joined the Waveney at Geldeston.

Below this there are only very short streams. One comes from the Windle Hills nearly 1½ miles eastward of Gillingham Church: another from Aldeby: another from S.E. of Burgh St. Peter (where that place is marked on Map 176); all these flowing southward, into the easterly flowing river.

After turning northward the Waveney may receive some water that oozes out of the Crag and Drift sand bordering the marsh, and finally there is *The Landspring Beck*, a short stream starting in Glacial Sand westward of Haddiscoe, flowing south-eastward and then eastward across the marsh.

Turning to the tributaries on the left or northern side of the Yare (using that name for the stream below Hardingham Station) there is first a tiny stream from the Boulder Clay between Runhall and Brandon Parva and then another from eastward of Welborne. And these are the only tributaries until the Yare passes round Norwich,

though there is probably a large accession of water from the Chalk along the greater part of that course.

On the eastern side of the city, however, the Yare receives its largest tributary. *The Wensum* indeed is really the larger river of the two, rising in the western part of the county in the mostly gravel-covered Chalk of West and East Rudham: perhaps higher in bourne-years.

It winds eastward, mostly through Drift (and that chiefly gravel), by Tatterford, Shereford and Fakenham, about two miles below which town it turns south-eastward for some four miles, between Great and Little Ryburgh, still chiefly through Drift gravel, but at last cutting through to Chalk, and near Guist turning southward to near Worthing, where it takes a general course south of east, with much wandering and still mostly through Drift, but in many places cutting through to Chalk, by Swanton Morley and Lyng, nearly to Attleborough, before reaching which place it turns south-eastward and flows through Chalk with a set of bold loops at Ringland, Taverham, Costessy and Drayton: then by Hellesdon to Norwich and going through the city, in smaller loops, to join the Yare on the eastern side. It is up the last loop of the Wensum that the water-traffic along the Yare from Yarmouth to Norwich goes.

The Wensum, including the tidal Yare, in which it flows from Norwich to the sea, is the longest river of the county, and of course has various tributaries. The first on the right side is from Drift and Chalk and has two head-waters, that on the west from Weasenham St. Peter, that on the east from Horningtoft and Whissonsett; these easterly and westerly streams meeting at South Raynham and the combined stream taking a short northerly course, between West and East Raynham and by Helhoughton, to the Wensum just below Tatterford, where the tributary impresses its northerly course on the main stream for a short way.

There is then only a set of short streamlets, from Boulder Clay drainage, opposite Fakenham, at Great Ryburgh and North Elmham (this largely from Glacial Gravel?).

Then we come to a fairly long, though apparently nameless stream, the result of the drainage of a large Drift-tract. Its head-waters are from the Boulder Clay of Great and Little Fransham, and it flows from the former place eastward, by Wendling, toward East Dereham, with many additions on its right, or southern side. Near East Dereham it turns in a more or less northerly direction, by Gressenhall, with a short addition from near Longham, to Worthing, just before reaching which place it receives a tributary named *The Black Water* (not to be confused with the Blackwater which belongs to the Yare, see above, p. 9). This starts from Drift-drainage at Brisley (the little branch here being called *The Panford Beck*), at Stanfield, East Bilney and Beetley. It is curious that the smaller stream should be endowed with two names on the Ordnance Map (146), whilst the larger one, into which it flows, is not honoured with any.

The Penny Stop Beck, an insignificant stream from the Drift south-eastward of Swanton Morley, joins the Wensum nearly opposite Bylaugh, and below this there is next to nothing in the way of streamlets for several miles.

The Tud drains a long tract of Boulder Clay. It starts westward of Westfield and flows in a fairly direct easterly course near Yaxham, Mattishall Burgh, Hockering and East Tuddenham, by Honingham, where it cuts through to Chalk, soon leaving the Boulder Clay tract, and joining the Wensum opposite Hellesdon. In the lower part of its course this stream very nearly approaches the Wensum, at the loop between Ringland and Taverham (half a mile), while at the Costessy loop the distance between is less than a quarter of a mile.

H. B. Woodward says (in the Norwich Memoir, p. 3) that in Norwich the Wensum formerly received the Cockie stream, which traversed the valley in which the market-place is situated, and fell into the Wensum near the 'Duke's Palace' Inn.

On its left side the Wensum receives the short *Tat*, but little below its own source. It rises in the Chalk at Wicken Pond, flows S.E., by Tattersett, and joins the Wensum just below that village. As it imposes its name on Tatterford, a little below the junction, it looks as if the name Tat ought to be applied to the whole stream, at all events to this high part of it.

A small stream, from Drift and Chalk, in the neighbourhood of Sculthorpe flows southward and then south-eastward to the Wensum above Fakenham.

Another small stream, of various branches, from the Drift northward of Stibbard, flows at first westward, that is in a reverse direction to the flow of the main stream above; but soon turns south-westward to the Wensum W.N.W. of Little Ryburgh.

The next stream starts from the Drift S.E. of Swanton Novers and flows southward, with accessions by the way from between Hindolveston and Wood Norton, to Foulsham, round which last place it turns westward, by Twyford (where it receives a stream from Wood Norton) to Guist, where it cuts through to Chalk a little above its junction with the Wensum.

Starting from the Drift at Billingford on the west, and between that place and Foxley and Bawdeswell on the east is a set of streams, two with a northerly, but the combination with a westerly, flow, to the Wensum southward of Billingford.

The next tributary is a composite stream. One branch starts in the Boulder Clay tract near Foxley and flows south-eastward. Another from the Drift eastward of Themelthorpe, flows south-eastward to west of Reepham, cutting through to Glacial Sand, etc., and then southward, and at last cutting through to Chalk. A third and rather longer one starts in places on the Boulder Clay between Heydon and Sall, the combined stream taking a southerly course to the west of Cawston and then a south-easterly one by Reepham and Whitwell, to Whitwell Common, where the joint-stream, formed by all three branches, turns south-eastward and cuts through to the Chalk on its left side (receiving a short tributary from Great Witchingham), joining the Wensum above Great Witchingham Hall and imposing its direction on the main stream.

But little below is a stream with two branches; one from west of Brandiston, flowing southward through Glacial Sand, etc.; the other and longer one, throughout over Glacial Loam, southward from Smuggler's Hole, north of Haveringland toward Felthorpe, and then westward by Swanington, to the other branch between

the last place and Alderford, the combined stream then cutting through to Chalk and joining the Wensum a mile S.S.W.

Finally comes a very short stream flowing S.S.E., chiefly in Chalk, at Drayton.

H. B. Woodward says (Norwich Memoir, p. 3) "The Yare and Wensum together drain an area of 533 square miles." J. H. Blake (Yarmouth Memoir, p. 1) credits the Yare (presumably including the Wensum) with about 529 square miles; but measurements made on the old maps must be received with some caution.

Below Norwich the Yare has a short Crag-tributary (? *The Yer*) from near Great Plumstead and from Blofield Corner, the two branches uniting and the stream then flowing south-eastward to the river below Brundall. A still shorter Crag-stream comes from N.W. of Southwood church southward to the river below Cantley.

The last tributary of the Yare, which joins it only just before reaching the sea, is *The Bure*, which is tidal up to Wroxham bridge. "The Tides of the River Bure and its Tributaries" forms the subject of a paper by R. Gurney, and D. A. G. Innes follows this with a paper on "Tidal Action in the Bure and its Tributaries."[1] These should be consulted by anyone needing detailed information on the Bure and the Broads.

This river, with its tributaries, carries the drainage of the north-eastern part of Norfolk. It starts in the Drift tract just south of Melton Constable, and takes a slightly meandering course but little south of east for some miles, by Briston, Saxthorpe and Itteringham, and then, cutting through to Crag, to Ingworth, where it turns south-eastward for a like distance, but with a rather more irregular course, by Aylsham (below which town it cuts through to Chalk) Burgh next Aylsham, Oxnead, Buxton, and Coltishall, to Belaugh, where it takes a sharp bend round, by Wroxham and Hoveton St. John, by Wroxham Broad, Hoveton Great Broad and Hoveton Little Broad, and by Horning through the broad marsh to near Thurne. Then it turns southward to near Acle, and then eastward, by Stokesby, to just north of Yarmouth, where it turns southward to the Yare at the north-western part of that town. After passing Wroxham the Chalk is lost, beneath the Crag, and the latter is lost, under Drift, near Thurne.

On its right side but a few miles below its start, at Melton Constable, the Bure receives a Drift-tributary consisting of various branches. One of these starts near Melton Hall and flows E.S.E. to near Thurning. Another starts in the Lake south of the Hall and flows south-eastward beyond Hindolveston; then turning eastward, round Thurning, with a short accession from south of Hindolveston Wood. A third branch starts from south of Guestwick and flows N.N.E. to Thurning. This composite tributary to the Bure is a curiosity in nomenclature, for on the old map (68, S.W.) the second branch is called *The Bure* and the third *The Thurne* (a name that belongs to a more important tributary much lower down), and on the newer map (147) the short combined stream, which flows N.N.E. from Thurston to the Bure (of the newer map)

[1] *Trans. Norf. Nat. Soc.* 1911, Vol. IX., pt. II., pp. 226–243, map, chart, diagram. *Ibid.*, pp. 244–262.

is called *The Black Water*, the third stream of that name in the Basin of the Yare. *See* above pp. 9, 12.

Below this are very short Drift-streamlets, from S.S.W. of Corpusty, from Oulton, and from southward of Blickling, all three flowing somewhat east of north.

The Mermaid is somewhat longer, starting north of Manor House (at the eastern boundary of the parish of Cawston), flowing, in a more or less easterly course, to the Bure northward of Brampton. It seems to rise from Drift Gravel, and then flows over Drift Loam, until in the lower half of its course it cuts through to Crag and then into Chalk.

The next tributary starts from Drift Gravel and Loam at various places westward of Hevingham; the combined streamlets cutting through to Crag and joining together at Westgate Street (Hevingham Street of the old map) where the combined stream flows E.N.E. to the Bure at Buxton, soon cutting through the Crag to the Chalk.

A few miles lower down is a rather longer tributary (? *The Hor*; but not named on the map). One of its branches starts in Drift less than half a mile S.W. of Botanybay (by Horsford Heath) and flows, at first, north-eastward and then south-eastward over Drift Loam, cutting down to the Crag at Newton Common and to the Chalk a little further on, to Spixworth Bridge. The other branch starts by Felthorpe Church and in the other little valley to the east, apparently from the Drift Gravel, and then flows over the Loam, in a general easterly course, curving first slightly southward, and then slightly northward, by Horsford, and then cutting through to Crag, by Horsham St. Faith, to Spixworth Bridge, where the combined stream takes an easterly course, through Chalk to the great loop of the Bure at Wroxham Hall, receiving on the way a tributary from the Crag near Rackheath Park, which flows northward, soon cutting through to Chalk.

A short Crag-stream starts more than a mile westward of Panxworth, flows for a little way southward, and then turns E.N.E. by Panxworth and through South Walsham Broad, whence it flows through the marsh northward to the Bure. A short branch runs from Hare Fen through the village of South Walsham to the Broad.

The last tributary to the Bure, on its right side, is a short stream, from the Drift of Beighton, Moulton, and Halvergate, the combined stream reaching the marsh northward, below Acle.

On the left, or northern, side of the Bure the first tributary is a short one, from the Drift southward of Edgefield, with a southerly flow. A like short stream brings the water of the Drift of Little Barningham and Mannington southward to the Bure at Itteringham.

The *Scarrow Beck* drains a considerable area of Drift (chiefly the Loam and Clay of the Contorted Drift) by means of a more or less parallel set of streams, with a general south-easterly flow, which unite into one, with a southerly flow. The head-waters are (*a*) from near Aylmerton (not 2½ miles from the coast) on the north to Metton, whence the southerly course is taken; (*b*) from N.W. of Gresham (also not 2½ miles from the coast) by Sustead to S.W. of Metton; (*c*) from W. of Gresham, by Thurgarton Hall, to the

N. of Hanworth; (*d*) from between Bessingham and North Barningham, by Thurgarton, to Aldborough; (*e*) from Town Barningham, by the S. of Aldborough, with a small westerly addition from Wickmere. The southern-flowing stream, which receives all these on the west, but practically nothing on the east, runs from near Metton, by Hanworth, Aldborough and Erpingham to the Bure south of Calthorpe.

The next tributary, though somewhat longer, is without a name (on the map). Like the last it drains a considerable Drift-tract, but unlike it has streamlets on both sides and very short. It starts just N.W. of Roughton (less than 3 miles from the coast) and flows fairly regularly southward, through the village, through Great Water (Gunton Park), between Colby and Suffield, by Tuttington, where it cuts through the Drift to the Crag, and on to the Bure nearly a mile below Oxnead. Its side-streams are of no importance, except the last, which starts from the Drift N.N.E. of Swanton Abbot, flows south-westward by that village, and then, cutting through into Crag and at last into Chalk, joins the main stream only just above where the latter joins the Bure.

A short stream flows from the Crag and Drift near Sco Ruston, in a south-westerly direction to the Bure at the eastern part of Coltishall. Another starts near by, in the Drift, westward of Ashmanhaugh, flows south-eastward (cutting down to Crag) through Burntfen Broad, and then turns south-westward to the Bure, through Hoveton Little Broad, with a slight accession from the west.

The Ant, an important tributary, has its headwater in the Contorted Drift between Southrepps and Thorpe Market, within $2\frac{3}{4}$ miles of the coast. It flows nearly south-eastward, by Bradfield and Swafield, receiving between those places, a shorter stream, on the right, which may perhaps have the right to the name, as it passes through the parish of Antingham. It continues eastward of the town of North Walsham, still over Contorted Drift; but cuts through to Crag some way above Honing, a mile or so below which place it takes a more southerly course, through Barton Broad, to some extent again through Contorted Drift, and joins the Bure near Horning Hall.

On its right side the Ant has a short tributary from south-west of Worstead, which flows eastward, mainly through Crag, by Smallburgh and Dilham, to the main stream.

Another short tributary starts in Contorted Drift westward of Beeston Hall and flows eastward, cutting down into Crag, through Neatishead, into Barton Broad.

A still shorter stream starts from the Crag north-westward of Alderfen Broad and flows south-eastward, through that Broad, to the river.

On the left side of the Ant there are only trifling local runlets from the Drift for some way down. Then we have a stream starting from Crag north of Ridlington, nearly within half a mile of the coast, and flowing southward to the main stream south of East Ruston. This stream may already have suffered from the cutting back of the land. It has a short addition southward of Ridlington.

A little lower down a short stream, from the Drift northward of Brumstead flows south-eastward to the river. Another short two-headed stream, from the Drift of Stalham and from the Crag of Sutton feeds Stalham Broad, which is close to the Ant.

A very short stream, notable only because it forms the small Crome's Broad, is the last tributary.

Passing now to the next tributary to the Bure, *The Thurn* or *Hundred Stream*, we are faced with a stream that has suffered great loss from the encroachment of the sea along the low land from Happisburgh to Winterton. So much is this the case that all the higher streams that go to make up this river have been lost, and the waters that remain are mostly at about the level of the sea. The most distant head-water is in the Contorted Drift northward of Lessingham and very near to the coast, whence the flow along the "New Cut" is south-eastward to Brograve Level, accessions being received, on the left side, from N.W. and S.E. of Palling, from very near to the coast. Then it takes a southerly turn, through Horsey Mere and Heigham Sound, at the top of which it receives the water from Hickling Broad, on the N.W., whilst just beyond the southern end of the Sound it is joined by the branch named the Hundred Stream on the new map (148), so called because it separates the Hundreds of Happing and West Flegg, and which perhaps was once the main stream. This starts from close to the coast at Bramble Hill, whence it flows south-westward, imposing that direction on the combined stream, to near Thurne, where it joins the Bure

The drainage of a Drift tract flows southward through the conjoint Ormesby, Rollesby and Filby Broads and then south-eastward through the marsh, where it rejoices in the name *Muck Fleet*, to the Bure west of Stokesby.

Lastly a short stream from the Drift north-westward of West Caister flows southward and through the Marsh to the Bure southward of that place.

It has been estimated that the whole drainage-area of the Bure is 337 or 338 square miles; but this estimate was made from the old map: one would like to have measurements from the newer ones.

Details of great part of this river and of its lower tributaries are to be seen in the papers by GURNEY and INNES, referred to on p. 14.

METHODS OF WATER SUPPLY.

Besides the two ways of getting water with which we are concerned in this Memoir, by means of wells or springs there are other methods in use in Norfolk, surface-waters being taken to a large extent.

Though there are only two large cases of surface-supplies, those happen to be the largest two supplies in the county, and both are in the hands of Companies. Norwich gets its water supply from the River Wensum, at Heigham, and according to the Local Government Board Return of 1915, p. 207, the daily average taken was 2,278,593 gallons, part of which went outside the city, to Catton, Cringleford, Hellesdon, Sprowston, Thorpe, Trowse and Whitlingham. Yarmouth depends

on the River Bure and Ormesby Broad, and, according to the Return of 1915 (p. 194), the daily average quantity taken was 1,524,458 gallons, part being for the outside places of Caister, Ormesby St. Margaret, and Ormesby St. Michael. W. L. SUTTON tells me (1920) that the quantities now taken by Norwich and Yarmouth are 2,655,000 and 2,141,161 gallons respectively.

The third largest supply, that of Lynn (in the hands of the Corporation), used to be taken from the Gaywood River; but that has been given up for many years, in favour of a well-supply, the polluted stream having been the cause of fevers (*see* p. 46). The river, however. seems to be still partly used in Gaywood.

Other places with a river supply are Castle Rising and Westacre, from the Babingley River, in private hands; Hilgay, from the River Wissey; Narborough, from the River Nar; Southery, from the River Ouse; Welney, from the River Delph; and West Welney, from the Hundred Foot River. "No doubt other parishes adjoining rivers and streams also utilise these, more or less, as sources of supply" (DR. J. T. C. NASH, Annual Report, to the County Council, for 1914, pp. 25, 26).

Of the supplies other than those above-noted, those for Cromer, Diss, East Dereham, Hunstanton, and Thetford are in the hands of the local authorities, as also several smaller ones, whilst those of Sheringham and Swaffham belong to companies, some small ones, as those for Northrepps, Sandringham, Trowse and West Bilney, are in private hands.

As would be expected in an agricultural county, much of the surface of which consists of clay, many small places depend to a great extent on ponds for their water-supply, and, in the Report above-quoted, DR. NASH says:—"Ponds are mentioned among the sources of supply in the reports (of the Medical Officers of Health) for Depwade R.D., Loddon and Clavering R.D. (parishes of Hales, Hedenham, Mundham, Thwaite, Topcroft, and Toft Monks)."

In the Memoir on the Geology of Fakenham, etc. (1884, p. 50), it is said that at Colkirk, in some places, reservoirs are dug in the Boulder Clay for water-supply.

In many places too water must be taken before it reaches the earth, rain-water being often the most available supply. Again to quote from DR. NASH's Report (p. 27), speaking of the Downham Market Rural District, "In the lowland or fen the inhabitants depend on water collected from roofs stored in cisterns: when this supply fails they have recourse to river water."

The water for many breweries and other manufactories is got by means of wells, and various public or half-public institutions depend on similar supplies.

GEOLOGIC FORMATIONS.

General Account.

The greater part of Norfolk is in the large geologic tract known as the London Basin, including therein the Chalk, which forms the basin as well as the Tertiary beds which fill it. The western part only is outside, beyond the Chalk, and consisting of older Cretaceons beds and Jurassic (Kimeridge) clay.

The most notable formation is the Glacial Drift, which here reaches its highest development in the country, not only in complexity of structure, from its many divisions, but also in its thickness, as a continuous sheet, without having regard to various places in other counties where very deep channels of Drift occur. The Glacial Drift occurs over most of the county.

Its Pliocene deposits are also notable, though not from the point of view of water, especially as containing one division, the Forest Bed, which does not occur elsewhere.

The great thickness of the Upper Chalk is remarkable, being far above that in any other part of the Basin.

In the following list, the figures in brackets show the thickness of some of the beds. They are taken from a Geological Survey Memoir that deals specially with that subject.[1]

Recent	Coast Deposits ...	Blown sand.	
		Beach sand and shingle.	
	Alluvial Deposits (up to 120 feet	Alluvium.	
		Peat.	
		Fen silt.	
Pleistocene ...	Post Glacial Drift	Loam or Brickearth.	
		Marl.	
		Marine clay and loam.	
		River gravel and sand.	
	Glacial Drift ... (up to 300 feet)	Plateau gravel (over Boulder Clay).	
		Gravel (over Boulder Clay) and Eskers.	
		Boulder Clay.	
		Gravel and sand.	
		Loam and Marl.	
		Contorted Drift. Marl (or calcareous masses) clay, and loam, with nests of sand.	
		Brickearth, stony loam and sand.	
		Pebbly gravel.	
Pliocene	Norwich Crag ... (up to 208 feet)	Pebbly gravel and sand, with clay.	
		Chillesford Clay.	
		Crag and sand.	
Cretaceous ...	Chalk	Upper Chalk (1,150 feet).	
		Middle Chalk (100 to 200 feet).	
		Lower Chalk	(56 to 125 feet).
		Chalk Marl	
		Red Chalk	(4 to 60 feet).
		Gault	
	Lower Greensand (93-170 feet)	Carstone.	
		Clay.	
		Sand.	
Upper Oolitic		Kimeridge Clay.	

[1] On the Thicknesses of Strata in the Counties of England. . 1916, p. 97.

Besides the above the Pliocene deposit known as the Forest Bed Series, which comes in between the Crag and the Drift, and which is peculiar to Norfolk, occurs in the great northern coast-sections only, not coming out to the surface anywhere; and the following old Tertiary beds (between the Crag and the Chalk) have been proved in many wells; but they do not come to the surface, being wholly hidden under the Drift and Crag.

Lower Eocene	...	London Clay (310 feet). Reading Beds (46 feet).

As yet no deposit older than the Kimeridge Clay has been proved, though the lower part of the clay in the deep boring at Lynn may be Oxford Clay. These Jurassic clays have been proved to 630 feet.

No boring in Norfolk has yet reached those older rocks, the occurrence of which, next beneath Cretaceous beds, has been proved in the neighbouring county of Suffolk. From the fact, however, that the deep boring at Lowestoft, the nearest to Norfolk of the Suffolk borings, has reached to a very old Palæozoic rock, next beneath Lower Greensand,[1] one may infer that something of the same sort is likely to occur in the neighbouring, or south-eastern, part of Norfolk. The prospects of finding Coal Measures in Norfolk has been noticed by H. B. Woodward;[2] but it must be remembered that since he wrote the old rock at Harwich has been recognized as of older date than Carboniferous, allied to rocks at the newer borings of Culford, Stutton and Weeley[3] and at the still later one at Lowestoft.

Water-bearing Beds.

Although of course it is to the permeable beds that we look for a supply of water, yet it sometimes happens that beds which are mostly impermeable give small supplies. The various clays have here and there beds of a more sandy sort, which allow of slow infiltration, and many such occurrences happen with the Boulder Clay, which forms so large a part of the surface of Norfolk. In places too this deposit is very chalky. Strictly speaking all beds are water-bearing, but for practical purposes that term is confined to those that are generally so, in distinction to those which are so only rarely and slightly.

An interesting case of this sort has been recorded by S. B. J. Skertchly, from whose remarks (in the Fenland Memoir, 1877, pp. 241, 242) the following note is condensed.

At Walsoken brickyard (at the far western border of Norfolk), near Wisbech, pits are sunk in the clay (of the Fen Silt), and in 1859, a bed of fine sand or silt was pierced at a depth of 15 feet. From this a strong salt spring rose, the water of which was much salter than that of the river near by, and this, mixing with the fresh water

(1) Summary of Progress. Geol. Survey, for 1912, pp. 87, 88.
(2) Geol. Survey Memoir, The Geology of the Country around Norwich, 1881, pp. 168, 169.
(3) *See* the Water Supply Memoirs for Suffolk, 1906, pp. 41–43, 140–142, and for Essex, 1916, pp. 184, 343, 344.

in other parts of the pit, made the whole so brackish as to kill the pike, though carp, tench, and insects seemed unaffected.

Shortly after this incursion of salt water prawns appeared, and it is supposed that their ova were embedded in the marine silt, kept alive by the salt water with which it was charged, and hatched on the recurrence of favourable conditions. The prawns have abounded since.

The pits are about three quarters of a mile from the Roman bank and 1½ miles from the River Nene, up which the same species comes with the tide.

There are many pits in this district in which the water rising from the silt is brackish, but not another case in which living marine organisms were found. In some cases communication with the sea is kept up by beds of quick silt, and the water of wells becomes brackish during high spring-tides; but here this seems not to be the case.

Shingle Beaches.

In treating of the beaches and dunes of Blakeney Point A. E. Carey and Prof. F. W. Oliver, say "A feature of no little interest is the fact that fresh water can generally be obtained by digging wells in these shingle lows. In Long Low near the Lifeboat House a row of four such wells was dug in July, 1914, and they have continued to yield an inexhaustible supply of good potable water since that date. The level of the water in these wells rises and falls with the tidal cycles, showing a lag of about three days. That is to say, three days after the highest spring tide the wells attain their highest, and three days after the lowest neap their lowest level, the oscillation in the wells being from 15 to 20 inches. It is evident that the fresh water is floating on the salt, and it is remarkable that it should not undergo appreciable contamination."

"Shingle beaches above tide marks are in general drenched with fresh water, and so far as our experience goes show no abatement even in seasons of prolonged drought such as the summer of 1911. It may be conjectured that shingle has the property of condensing dew internally, a property perhaps shared by the sand dune."[1]

Gravels and Sands (Drift and Crag).

Beginning at the top of the geologic series we may here group together all those varied deposits of a gravelly and sandy character that as a whole occur throughout the county as scattered patches or as sheets, hiding the older Tertiary and the Cretaceous beds, and resting indifferently on the various members of these.

For our purpose it does not matter whether they are Post-Glacial, Glacial, or Pre-Glacial in age, or what may be their origin; subjects open to much geologic discussion and a fruitful source of controversy. All we are concerned with is, that though widespread in distribution they are individually of no great thickness, that they vary in character, are generally irregular in their ways, and often divided up by more or less impermeable beds.

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(1) Tidal Lands, 8° *Lond.* 1918, p. 226.

Clearly then they are unlikely to be the source of any large supply; but for small supplies they are of great service, for in many places no other source seems to be practically available.

Nor need there be any failure in the quality of the water, provided that it is kept free from contamination. In this Nature takes a part, and where the gravels and sands are found below Boulder Clay, or other more or less impermeable bed, surface-pollution cannot occur, and properly made wells sunk through the clay will yield a good water.

It has been well said, by an authority on Norfolk waters, that "the sands or gravels which occur, in many instances, below the clay, are plentiful in water supply of good quality. The reason for this is that there is a considerable amount of lateral filtration extending over long distances, and hence a large amount of oxidation of organic matter takes place, and the result is a water of very fair organic purity."[1]

Where, however, the gravel and sands are at the surface, of course they are open to pollution, as well as to the reception of rain, and precautions against contamination should be taken before water is drawn from them. For the want of such precautions many a fair source of water-supply has been fouled.

Perhaps though one would now hardly go as far as the above-quoted author when he continues thus:—"This class of well (through clay) is the only one beside the true chalk wells which ought to be tolerated as a water supply for domestic purposes in this district (= the county); because, if a well is sunk direct into porous alluvial soil or gravel, it matters very little how deep it is, it is essentially a surface well, and the soil being itself charged with organic matter from manure applied agriculturally, and other sources of impurity occurring on its surface, cannot oxidize the polluting matters in sufficient time to be of any use."

Mr. Sutton goes on to say (pp. 89, 90) that in a district like Norfolk "where there is a great depth of soil which has been brought to a fine state of division . . . . the rain falling upon the surface is speedily saturated with soluble matters, and such waters are, as a rule, extremely hard, from the presence of lime and magnesia salts, oxide of iron, alumina, and silica. When these surface waters find their way into the solid chalk, or into the sands lying below the surface clay, they become considerably softened by mechanical filtration. But what is of still more importance for drinking purposes is, that the dissolved organic matters which they at first contained are either entirely removed or are oxidized into harmless mineral compounds". . . .

"There are some districts in Norfolk which possess great peculiarities with respect to the character of the surface water. Cromer is an instance—the waters existing in the soil there to a considerable depth are very heavily loaded with soluble salts of soda, potash, lime, magnesia, iron, alumina, &c. The water is excessively hard, and is also unpalatable from the presence of a great excess of organic matter derived, undoubtedly, from the highly fossiliferous beds in which the water is accumulated. The soil

[1] F. Sutton, *Proc. Norwich Geol. Soc.*, 1879, pt. iii., p. 87.

appears to be entirely free from oxidising power, and hence, until these beds are passed to a considerable distance into the chalk there is no chance of obtaining pure or palatable water. These waters contain also large quantities of sulphates, arising from the decomposition of pyrites, &c."

Some of the Geological Survey Memoirs (on the sheets of the old map) contain remarks on water-supply from Drift in various parts of the county, and these are now brought together.

In dealing with South-Western Norfolk (Sheet 65) I said in 1893 that the gravels and sands are largely used for private supplies, many villages being on them, or partly so. As long as houses are not too near together, and cess-pits are at a reasonable distance from wells, such supplies may be good ; but it is unlikely that such a state of things is general.

Of the neighbourhood of Diss (Sheet 50, N.W.) in 1884, F. J. BENNETT said : "The water-supply comes chiefly from the Glacial sand and gravel below the Boulder Clay ; the quantity in many places is great, and the quality good."

Of the Cromer district, in 1882, C. REID has said : "The greater part of the area is supplied from shallow wells, sunk till a spring is met with in the contorted beds (Contorted Drift). This water, though probably wholesome, is hard and generally ferruginous, so that, till one is accustomed to it, the taste is very unpleasant."

On the country around Norwich (Maps 66, N.E. and S.E.). H. B. WOODWARD has made the following remarks (1881).

"Where the Chalk is not exposed at the surface, nor covered with Alluvial deposits, it is almost everywhere directly overlaid by the Crag Series, the pebbly sands and gravels" of which "furnish a supply of water to wells from 10 to about 100 feet in depth, and this is supported by the Chalk itself, which being penetrated a few feet may serve as a reservoir. Over the greater part of the area the Crag Series is covered with Glacial deposits (brickearth, sand, gravel, and boulder-clay), and where these are of an argillaceous character, the strata are free from all surface contamination. . . ."

"The Crag Series . . . . contains beds of laminated clay . . . . at inconstant horizons and of uncertain and very limited extension, which may act as local supports for the water-supply, or as checks to the percolation of water charged with organic impurities, where no Glacial clays occur above."

"Over almost the entire area embraced by Quarter-sheet 66, S.E. (Loddon, Long Stratton, etc.) where the chalky Boulder Clay appears at the surface, the Crag series might be expected beneath at depths of from 10 to 100 feet, and indeed it yields much of the water used in that district."

"The . . . . Glacial sands and gravels resting on the Lower Glacial Brickearth or Contorted Drift, yield supplies of water to wells varying in depth from about 10 to 30 feet. Where covered by the chalky Boulder Clay . . . . the water would be protected from surface contamination. . . . ."

"Water obtained from the sand and gravel on the chalky Boulder Clay is liable to the same objections as that derived from the sands and gravels that overlie the Lower Glacial brickearth, when there is no superincumbent layer of clay.

"The shallow wells sunk in valley-gravels, as in some of the lower parts of Norwich . . . are almost invariably subject to contamination, and the water should not be used for drinking purposes."

The Medical Officer of the Erpingham Rural District reported, in 1913, that, except for Kelling (*see* p. 55) in "almost every other village in the District the water is derived from shallow wells in the Glacial drift. The water therefrom varies according to the position of the well, the care taken in its construction and the measures taken to protect the water from contamination; it is good, bad or indifferent in direct ratio to the skill expended in selection of the site and construction of the well."

Dr. NASH'S remarks on East Harling, which are of a general nature, and not confined to that place are given on p. 92.

The Chalk.

We now come to the geologic formation which is not only the chief source of water-supply in Norfolk, but also in the whole of the South-East of England. It has, indeed, been said, by the former Public Analyst of the county, F. SUTTON, that so far as this county is concerned, "we are practically confined to the Chalk formation for the most wholesome water supply, and when supplies can be drawn from it without surface contamination the water leaves scarcely anything to be desired except on the score of its hardness. I do not believe, however, that this is a matter of any consequence as respects health," (1) a conclusion that later research has justified, as has been pointed out by DR. J. C. THRESH in another Memoir, to which the reader is referred for details (2).

Water is absorbed readily by chalk, and one of the results is the general dryness of the surface over a wide Chalk-tract, the comparative dearth of streams and the abundance of streamless valleys. The rain that falls on the Chalk soon passes downward, until at last it reaches that part of the formation which is saturated with water. A good water-tight bottom is provided, in the shape of the Gault clay, and the lowest part of the Chalk itself is clayey; so that the water can only escape from the Chalk by means of springs, through which the underground water again appears at the surface.

The outflow of water from the Chalk depends but little on the division of the formation: it is determined by the relation between the surface of the ground and the saturation-level in the Chalk, this being the level to which water percolating through the rock sinks, until it reaches a level where the Chalk is fully charged with water and can therefore pass no more downward.

The saturation-level, or water-table, is naturally irregular, from the frictional resistance to the flow of water through the mass of the Chalk (more or less horizontally as well as vertically), and it roughly follows the changes in surface-level, though not varying to the same extent; it is higher under the high grounds, though there at the greatest depth from the surface, and it falls gently to the low grounds, though there nearest to the surface. It is

(1) *Proc. Norwich Geol. Soc.*, 1879, pt. iii, p. 86.
(2) The Water Supply of Essex, 1916, pp. 67–69.

greatly affected by seasonal changes, falling after dry seasons, rising after wet ones, the rise and fall being greater the higher the level of the ground.

When the ground sinks below the saturation-level there the water bursts forth in springs, and, as the saturation-level varies greatly from seasonal fluctuation over large tracts, springs at times break out much higher up the valleys than is usually the case. The lowest springs are in constant flow, though with changing yield, often to a great extent.

This change in the point of outbreak then gives rise to what are known as intermittent streams, or bournes, which have a variety of names in various districts. I do not know of a name special to Norfolk, although there are several such bournes in the county, enough to be worthy of a separate heading (*see* p. 37). Bournes have been described at some length in the Water Supply Memoirs on Hampshire, Kent, Surrey, and Sussex (supplement).

Whilst in sands water passes between the grains, in limestones this is not the case, or only to a very small extent, for in them as a general rule there is no distinct granular structure. The Chalk is no exception, and water finds its way through the rock chiefly by means of slight fissures, caused by the more or less vertical planes of jointing; some also travelling along the planes of bedding, especially perhaps where these are strongly marked by flints.

To get a large amount of water from the Chalk it is therefore essential to cut these fissures, and this is to be done by horizontal work, that is by the driving of headings below the level of saturation. Little of such work, however, has been done in Norfolk, in many parts of which the Chalk is at such a depth from the surface that horizontal work would be difficult and costly. Vertical work, by boring, is therefore generally resorted to, and as there is rarely a call for a large supply this is enough.

From the point of view of water-supply the Chalk of Norfolk consists essentially of two tracts, a smaller one on the west, where the underground water flows in a general westerly direction, with the gentle slope of the escarpment, and a larger on the east where it flows in a general easterly direction (but with a fair amount of variation) to the various valleys. At the north-western part of the county there is a sort of intermediate tract, with a more or less northerly flow, toward the sea. When the land extended further northward this tract must have belonged chiefly to the large easterly tract.

Speaking of the Chalk of Norwich, J. E. Taylor and A. W. Morant say "The recent drainage excavations prove that water percolates very slowly, and with great difficulty, through the re-deposited Chalk (which they describe as occurring at the top of the formation there). . . . In the hard or undisturbed Chalk the water sooner disappears, although in larger quantities, through the various joints and fissures, and along the horizontal beds of flint, until it reaches the level of saturation."[1]

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[1] *Geol. Mag.*, 1870, Vol. vii., p. 120.

The Lower Greensand.

Though having a length of outcrop (partly hidden by Drift) of over 26 miles, from south to north, in the western part of Norfolk, no public supply is taken from the southern end of this tract (in Map 65), whilst in the northern part only some springs are used, for partial supply (Dersingham). We may say, therefore, that the Lower Greensand is practically unused for public supply.

A good deal of water is thrown out from it, but much of this must be ferruginous. Some low-lying tracts are much water-logged, as around Leziate Fen.

As there are many places wholly or partly on this formation there must be a great number of private wells in it, or carried through Gault or Drift to it. It is a question whether wells in the Lower Greensand are not often too near cess-pits and other sources of pollution.

In the northern part of the outcrop (in Sheet 69) the formation is largely divided into two, as far as water is concerned, because of the thin clayey division in the middle, between the Carstone and the Sands.

At Downham Market a fair amount of water has been got from beds of stone or from sandy layers in the Kimeridge Clay. No older deposit yields any water in Norfolk.

SPRINGS.

General Remarks.

Springs are the spots where water that has travelled underground comes to the surface, and they have always been a subject of interest, and in many cases of importance. There is a fascination in the sight of clear sparkling water flowing out of the earth, and one can readily understand how, in old times, the apparent mystery of this led in some cases to a superstitious reverence and to romantic theories of origin.

Now of course the mystery has disappeared, at all events to geologists, and has been replaced by matter-of-fact explanations of the outflow of the water. Nevertheless, there are sometimes obscure points that want clearing up, and I often wish that our springs had more attention from observers.

The commonest form of spring is that which occurs where a more or less impermeable bed crops out from beneath a permeable one, as, for instance, Boulder Clay from beneath gravel and sand, or Kimeridge Clay from beneath Lower Greensand, and springs of this sort may occur at any level, high up the hills as well as low down the slopes.

But springs may also arise where there is no impermeable bed at the surface; it is enough that a permeable bed, reaching down to a low level, should be so saturated with water in its lowest parts that more water cannot sink into it, and, therefore, must flow out. This of course happens only where the surface of the ground has been cut down to the plane of saturation, and that is in comparatively low ground. It must be remembered that the most permeable bed, as, for instance, an open sand, when saturated with water opposes resistance to the entrance of further water just as much as does an impermeable clay. The like occurs too in such rocks as Chalk where valleys are cut down to saturation-level, and many of the springs to be noticed are of this sort.

Some of our principal springs have been noticed in Geological Survey Memoirs, and H. B. Woodward has written two short papers on the Springs and Spas of Norfolk.[1] These and other published sources will now be put under contribution, and the springs will be noticed, in geologic order, from the top downward; but it must be understood that nothing near completeness can be aimed at: it is enough to attempt an account of the more notable springs. Supplies of water that are got from springs are noticed under a separate heading (pp. 54, 55).

Drift.

Starting on the west and going generally eastward, as well as from south to north, we find many springs from various divisions of the Drift.

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[1] *Trans. Norfolk Nat. Soc.*, 1882 and 1883.

At Oxborough, about a third of a mile N.N.E. of White House (and about a mile westward of the church), there is a spring-head, the water of which flows out from reconstructed chalk (consisting of lumps of chalk in a matrix of the colour and consistency of putty), which is covered by some four or five feet of blown sand. This is in a tract of Boulder Clay.

There is a spring close to Tottenhill Row, N.W. of the village of Tottenhill ; so that there may be an outcrop of clay from beneath part of the gravel here ; but I did not find evidence enough to justify the mapping of clay.

Treating of the country around Fakenham, Wells and Holt (Maps 68, N.W. and S.W.), H. B. Woodward said, in 1884 : "Iron-stained waters are very common in the district, issuing from the ferruginous Glacial and Alluvial sands and gravels. A spring of this nature is met with north-east of Guist Bridge : one issues from the lower end of Rainham Lake, there is another at Holkham, and one south-west of Skitfield, Guestwick. The gravel of the Alluvium near Skitfield is stained red, and there are deposits of bog iron ore in the ditches. Such springs seem generally to flow out where there is valley gravel."

"Of springs whose virtues are entirely legendary, may be mentioned the 'Wishing Wells,' situated in the Abbey grounds at Walsingham. . . . . There are two of these wells situated close together in the Alluvial ground bordering the Stiffkey stream, and whatsoever virtue they possess is probably owned also by the little river which keeps up their supply. In the same enclosure of the Abbey grounds is a larger well, which may have been a baptistry, or a pool for healing the afflicted, or simply a bathing-place for dusty pilgrims; its original purpose has long been lost sight of." I am disposed, however, to take these as springs mainly derived from the Chalk.

"At Holt, Letheringsett, and Hempton there are more or less copious springs. That at Holt rises on the west side of the town, at the junction of marls and brickearths with overlying sandy and gravelly beds, all belonging to the Glacial period." The water "simply flows from the surface, through the porous strata, until arrested and thrown out by the marly and clayey beds beneath. It was remarked of this spring (in 1829) that it 'affords, in summer and winter, in drought or in wet seasons, an equable stream of very soft and very pure water.'"—(Chambers, "History of Norfolk.") *See also* below, p. 54.

"The spring at Hempton, which issues from the Glacial sands on the grounds of the Abbey Farm, was analysed by Mr. F. Sutton, and, although bright and palatable, it was found to contain minute quantities of iron . . . . which render it undesirable as a water for drinking."

"About 3 furlongs north of Stibbard church there is a spring known as 'Stibbard Spring,' by the stream to the east of the road between Stibbard and Fulmodeston. I was informed . . . . that people have walked miles to drink it."

Spring Farm, Attlebridge, in the valley of the Wensum, gets its name from the spring which occurs there.

At the Bath Hills, Ditchingham, near the Waveney "a spring of remarkably cold water was utilised for the bath there erected." (H. B. Woodward, Norwich Memoir.)

In the parish of Mundham, Thwaite Spring is marked on the old map (66, S.E.), but not on the newer one (162). The site is about three-quarters of a mile E. of N. from Thwaite church and is on Boulder Clay. "Mr. Reid says that, so far as he remembers, it is now merely a swamp."[1]

"I was informed by Mr. T. G. Bayfield that a spring of a petrifying nature was to be met with in the neighbourhood of Burgh Apton. No doubt it derived its calcareous matter from the chalky Boulder Clay." (*Ibid.* and Norwich Memoir.)

It is said that at Weybourne springs near the railway-station have for many years supplied water-power to a corn-mill near the beach. The water must come from Drift.

Of the Cromer district C. Reid has said (1882): "A few springs are given out at the base of the Boulder Gravel, especially near Mundesley. There are not so many of these as might be expected, for the contortions prevent the underlying beds from holding up the water, as each vertical bed of sand forms a sort of pipe to conduct the water to a lower level."

There must be a great number of other springs from the Drift and Crag, and it is to be hoped that many of these will be duly recorded by local observers.

Chalk.

Several springs have already been noted in treating of the rivers and streams. We will now notice those of the open Chalk-tract on the west of the county, starting from the south, nearly all of which contribute to streams with a westerly flow, that is, across the beds downward.

Valley of the Wissey.

I saw one set of springs half a mile west of Houghton-on-the-Hill church; and of the valley of the Wissey G. Barrow has said: "About North and South Pickenham powerful springs issue just above the stream-level, the one half a mile southward of the Hall, South Pickenham, being especially strong and forming a deposit of tufa." Presumably this is a spring that I have marked just up a tributary on the left side, by the parish-boundary, between Houghton and Great Cressingham.

"Another spring occurs lower down the valley about two thirds of a mile N.E. of Hilborough House (or Hall, and therefore in the parish of Great Cressingham). In the early spring the boundary of the alluvium is only a few feet above the saturation-level of the Chalk."

A spring seven-eighths of a mile S. of E. from Foulden church is marked by a small elliptical enclosure on the old map (65) and on the newer one (160) by a small wood.

A third of a mile E.N.E. of West Dereham church a spring, from near the base of the Chalk, on the southern side of the road, is marked in a like way on the old map, but not at all on the newer.

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(1) H. B. Woodward, *Trans. Norfolk Nat. Soc.*, 1882, p. 322.

A tributary of the Wissey starts at a spring or set of springs in the parish of Cockley Cley, at the head of the Alluvium about a mile above the Hall, and is shown by small round enclosures on the newer map (160). G. Barrow says that the height of this powerful spring shows "that the saturation-level in the Chalk must be fairly high here. This spring deposits much tufa, and is not known to run dry."

Valley of the Nar.

C. E. Hawkins has contributed notes on the springs in this valley, which were printed in "The Geology of S.W. Norfolk" in 1893.

"Half a mile south of Emanuel Farm, Castle Acre (Lodge Farm of the newer map, 146. The site is westward of Fiddler's Green, of that map), a spring rises in a field on the northern side of the road, just on the edge of the Drift (clay)," in a small side-valley.

"Springs also rise on the western side of the road about half a mile E.S.E. of South Acre church." This also is in a small side-valley.

"On the northern side of the river rather more than a quarter of a mile above the bridge at Narford, there are many copious springs, the quantity of water from which is so large that they form one of the chief sources of the Nar."

"Some fine springs may be seen on the western side of the railway a mile S.E. (S.S.E.) of Narborough Railway Station."

"A spring rises at the edge of the 'Turf Fen' (Marham Fen of the newer map, 160) half a mile S.W. of East Gate, not far from the Fox Inn," Marham.

"Half a mile nearer Marham (about three quarters of a mile N.E. of the church) are the springs that give the supply for the Wisbech Waterworks. These rise on the northern side of the road a little below a farmyard and a group of cottages: the water comes from the base of the Chalk in large quantity."

"Near Marham church there is another fine spring, on the western side of the road across the Fen."

Reverting now to my own notes: in the parish of East Walton there are many springs. I saw one $1\frac{1}{8}$ miles south-eastward of the church, and others to the north-west, near Summer End of the newer map (146). Further remarks on this district will be found under subsidences, p. 41.

Gaywood River.

At Gayton Thorpe water rises close to the top of the Lower Chalk at the head of a tributary-stream.

In the parish of Gayton there is a powerful set of springs at Well Hall, northward of the village, forming one of the head-waters of the stream. The water breaks out close above and at the farm, one spring coming out from under the northern wall of the farm-buildings. All but the higher springs are polluted by the drainage from the farmyard, a lamentable state of things, considering the natural purity of the water.

Other head-waters of the Gaywood River are a little to the north, in the parish of Grimston, the most southerly being the Sow's Head Spring (not marked on the newer map, 146). It is in a field not

half a mile northward of Well Hall and the water issues from a very hard solid limestone, in thick beds, which weathers to a creamy tint and is fossiliferous. The next spring is a little south of the church, and the chief springs in the village are just west of the church, as marked on the old map (65), and separated from the churchyard only by a road : clearly this set should come under the class of holy wells ! Here therefore, as at Well Hall, human ingenuity has done almost its worst for the water, most of which must flow at but little depth beneath the churchyard. At the spring-head not far north of the church there is hard grey bedded rock, gritty and shelly.

The following gaugings of three of the above-noted springs, kindly given by E. J. Silcock, were taken when he was the Engineer for Lynn. The figures stand for gallons a day.

——	Well Hall.	Sow's Head.	Grimston Church.
Minimum discharged at end of August, 1887 ...	612,000	166,500	460,000
On 13th January, 1893 ...	1,267,000	278,000	—
„ 25th March, „ ...	1,452,000	307,000	—
„ 20th May, „ ...	1,020,000	459,000	—
„ 10th July, „ ...	736,000	368,000	—

In a Report to the Corporation of Lynn of January, 1893 (in which the first two lines of the above figures were given), J. Mansergh says that probably in the driest seasons 700,000 gallons a day may be relied on from Well Hall and Sow's Head Spring together.

The increase in the yield of the Sow's Head Spring after March 25th, when it should have decreased, is owing to works carried out by Mr. Silcock, in order to find out whether the discharge could be increased, and if so to what extent. The following account of the work done is taken from his Report, dated May 26th, and printed in "Information respecting the Proposed New Water Scheme," 1893.

A trench was cut eastward from the spring into the hill-side, for 50 yards, when the chalk was found to be harder than was expected and the work was stopped. The gauging of March 25th was made a few days after the work had been begun and before the discharge had been affected by it. The yield went on increasing afterwards to the extent of about 50 per cent. A long drought, broken by only very few slight showers, had continued through the first week in March, the effect of which would be to reduce the yield, and the Well Hall yield had decreased 30 per cent. If the Sow's Head yield had decreased at the same rate, as it probably would have done had it been left alone, its discharge on May 20th would have been 215,000 gallons, and the increase from the work done in opening out the spring would be 115 per cent., that is, the yield would have been more than doubled.

Mr. Silcock told me that the heavy rainfall of February affected the springs before the 6th of March, This quick action, as compared with what happens in many Chalk-tracts, is owing to the gathering-ground being all fairly near the springs, which are fed

only by the rain that falls on the gentle slope of the broad escarpment.

Babingley River.

The higher part of this stream is intermittent, and its springs are noticed on page 37. In a tributary-valley on the northern side strong springs rise from the junction of the Chalk with the underlying marl (Gault) in Denbeck Wood, eastwood of Appleton (Appleton Hall of the newer map, 146, in the parish of Flitcham?). They are used for the supply of Sandringham House, etc. (*see* p. 54), and F. R. Beck, writing in 1894, stated that the water is excellent and that the supply never failed until 1893, when the quantity decreased seriously in August and failed altogether at the end of October, the deficiency being got over by pumping water from a shallow spring at the northern end of Sandringham House. The water began to flow again in the beginning of December, and the estate was again wholly supplied from the regular source on the 14th of that month.

Shorter Valleys.

A strong spring flows from the Chalk at Shernborne, "the water being doubtless held up by the thin layer of clay (unmappable on the one-inch map) which represents the Gault in this neighbourhood." (A. J. Jukes-Browne.)

Of the spring west of Bircham Newton, which is not marked on the newer map (146), C. Reid writes :—"From the character of the channel and the abundance of water-plants, the stream is evidently perennial. About 10 chains to the south there is a pond overgrown with sedges evidently on the site of an occasional spring-head. Lower down the valley at Fring more springs occur."

The chalybeate spring of Ringstead Downs, Hunstanton, is noticed on p. 35.

Northern Coast and Inland.

"The freshwater springs to which Wells-next-the-Sea owes its name, flow into the tidal creek at the quay, and may be seen at low water running through the piles, or rising out of the mud." H. B. Woodward, 1884.

Most of the inland springs have been noticed under the various rivers in whose valleys they occur.

B. Latham has given the level of 72 and 75 feet above Ordnance Datum for springs at Swanton Morley (Geology of East Dereham, p. 53).

Two springs at Norwich have been recorded by H. B. Woodward (in his Paper on Springs and in the Norwich Memoir), but in one case the source is not noted, and it may be from beds above the Chalk. It is convenient to keep them together.

Red Well Street: this is in the parish of St. Michael-at-Plea, also called St. Michael-at-Marpole, "that is *Much-Pool*, there being formerly a *Pool* where the Red Well now is. The *Pond* or *Pool* was filled up when the *Well* was made here, and the *Pump* was first fixed in 1629" (Blomefield's History, fol. ed. p. 719).

Again quoting Blomefield (p. 798) "close by the River on the left hand, going out of *Bishop's Gate*, is a spring of pleasant water,

formerly much resorted to." A stone conduit was erected over it in 1611. This spring no doubt issued from the Chalk, but as J. W. ROBBERDS has remarked, "whether in consequence of the excavations made in the bed of chalk, through which it flows, or from some hidden cause, it has been completely deserted by nymph of the fountain; the channel is left dry, and the stream has broken forth again at another point" (Stark's Scenery of the Rivers of Norfolk, 1828, 1834).

LOWER GREENSAND.

Near Blackborough End (Middleton Hithe of the old map) springs occur about three-quarters of a mile southward of Middleton church.

There is a spring about five-eighths of a mile N. of W. from East Winch church, where a copse is marked on the map.

At the eastern side of the little wood at New Spring (not marked on the newer map), and five-eighths of a mile from Gaywood church, there were, in 1886, some shallow cuttings in sand, which was cemented into an ironstone (a sort of bog-iron-ore) at the surface, probably from water thrown out as springs, through the occurrence of clayey beds beneath.

Eastward of Wolferton the bottom part of the sand-tract, north of the railway, is water-logged, so that it forms a very gently inclined boggy plain down to the marsh.

The wood in the little valley, about a third of a mile south-eastward of Dersingham church, is very springy and boggy, because of water being thrown out from the ferruginous sand by the underlying clayey beds, which have a narrow outcrop here.

S. B. J. SKERTCHLY noted springs thrown out from the top division, the Carstone, just eastward, and more than half a mile north-eastward of Lodge Farm (Lodge Hill Farm of the newer map), westward of the village of Snettisham.

MINERAL SPRINGS.

There is no sharp division between ordinary springs and those which are or have been thought to be of medicinal value, which latter got their reputation from containing rather more of certain solid matters than is usual. It is of interest, however, to treat of them separately, even where their mineral contents are comparatively trifling. They have a literature of their own, and in times past a value was attached to them that does not now hold: probably in Norfolk hardly any are now used. Several are notable only as of chalybeate character; but, as H. B. WOODWARD says, "at least two springs that attained some note were discovered in the county; one at Aylsham, and the other at Thetford." [1]

The following notes are arranged in the alphabetic order of the places where the springs occur.

Aylsham.

H. B. WOODWARD has said (in the Cromer Memoir, 1882):— "About 200 years ago Aylsham was noted for its Spa, a chalybeate

[1] *Trans. Norfolk Nat. Soc.*, 1882, p. 320.

spring situated a little less than a mile south of the church, and now commemorated in the name of Spa Farm. Probably the same spring trickles along the road-side, issuing from the Glacial Sands and Gravel that cover the rising ground east of the Farm, being thrown out by the Brick-earth (Contorted Drift) beneath. The Spa, it is said, was formerly much resorted to by invalids afflicted with asthma and other chronic diseases."

Cromer district (see also *Mundesley*).

C. Reid has said of the neighbourhood of Cromer (1882):—"Ferruginous springs are often given out by the Glacial Gravels, but I do not know of any other class of mineral waters in the area (Map 68, E.). In many places, especially near Overstrand, red stains are seen in the face of the cliff, marking the spots where ferruginous water oozes through the Boulder Clay."

There is a reference to the question, "Had Cromer ever a Mineral Spring?" by Walter Rye in the "Norfolk Antiquarian Miscellany," vol. ii, pt. ii, p. 391, in which some letters of 1633 refer to this; but no satisfactory answer seems to be given, and their writer went to Tonbridge (? T. Wells) instead of to Cromer.

East Dereham.

H. B. Woodward tells us that "in the churchyard is a well dedicated to Withburga. . . . . Although supposed by some to have been used as a baptistery, it is probable that this well . . . . was visited by the sick at certain appropriate seasons. . . . . Mr. J. H. Blake informs me that the spring issues at the junction of Glacial sand and gravel with the chalky Boulder Clay beneath."[1]

Easton.

In the bottom of the valley of the Tud, close to the boundary between the parishes of Easton and Costessey and more than a mile E.N.E. of the church of the former, is St. Walstan's Well. Whether the source is from Drift, Crag, or Chalk I cannot say.

According to H. B. Woodward's account (in his paper and in the Norwich Memoir) Blomefield (in his History, fol. ed., vol. i, p. 461) says that on Church Farm, a little below Bawburgh church (in the valley of the Yare), there was a healing spring, called St. Walstan's Well. The saint was born in that parish, and lies in Costessy Wood, and a spring rose at the spot. This must be the spring above noted; but I can find no other note of the Bawburgh one.

Gaywood.

The chalybeate Riffley Spring, just over a mile north-eastward of the church, at Spring Farm of the newer map (145), used to be visited for its water, which may rise from a sandy bed in the Boulder Clay.

Holkham, Seething, Shelfhanger.

H. B. Woodward says:—"Mr. R. J. Morton has informed me of a Chalybeate Spring at Seething; I learn of another at Holkham

[1] *Trans. Norfolk Nat. Soc.*, 1882, p. 319.

from Mr. A. J. Napier; and Mr. F. J. Bennett reports the discovery of one at Shelfhanger," [1] for an analysis of the water of which *see* p. 143.

Hunstanton.

At Barrett Ringstead Farm (a name that does not appear on the newer map, 129), at the western end of the marked valley of Ringstead Downs, a chalybeate spring, as A. J. JUKES-BROWNE remarks, "rises from the middle of the Lower Chalk probably about 20 feet above its base. The existence of such a spring in Chalk is unusual, and is probably in this case to be explained by the occurrence of a fissure traversing the Chalk and the Red Rock below so that there is a communication with the underlying Carstone (Lower Greensand). The ferruginous sandstone is probably saturated with water, and a local fissure may allow this water to escape upward and mix with that which percolates down the valley in the Chalk." The site is a little east of the road, 1¼ miles south of Hunstanton church.

Mundesley, &c.

CHAMBERS', General History of the County of Norfolk (vol. ii, p. 1333), mentions a mineral spring found in 1823. "The well which has been sunk is not more than 600 yards from the edge of the cliff, and is 56 feet deep." The present distance from the cliff is doubtful. H. B. WOODWARD says:—"I can learn nothing further concerning this . . . . but along the cliffs between Happisburgh and Weybourne there are numerous springs, some of which are conspicuously charged with iron-ore." [2]

In the discussion on this paper F. SUTTON said "that the nearest approach to medicinal waters occurring in Norfolk was to be found in the Glacial beds near Cromer and Mundesley," in which he had found "notable quantities of iron, soda, potash, &c., but still not enough to render them really medicinal." [3]

North Walsham.

It has been noted by H. B. WOODWARD that nearly a mile east of the town "is a place called 'Spa Common,' which is suggestive of a mineral spring, but I have not been able to obtain any information about it." [2]

Oulton.

BLOMEFIELD in his History of Norfolk (1769, vol. iii, p. 617) says:—"There is a fine spring called the Spaw, being a strong *Mineral*, much frequented formerly, before the Spaw at Aylesham (some four miles off) had gained its reputation."

Stibbard.

The chalybeate spring, from Glacial sand, here is noticed above, p. 28.

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(1) *Trans. Norfolk Nat. Soc.*, 1883, p. 325.
(2) *Trans. Norfolk Nat. Soc.*, 1882, p. 321.
(3) *Norfolk Chronicle*, 5 Nov., 1881.

Thetford.

The following notes are taken chiefly from F. Accum's Guide to the Chalybeate Spring . . . , 1819, pp. 59, 64, 65, 75, 159.

"The water of the chalybeate spa rises in a verdant meadow, at the east end . . . of the town, near New Place."

"The water taken fresh from the basin of its spring is as transparent as rock crystal, and perfectly colourless. Its taste is distinctly chalybeate."

"The temperature of the water before it reaches the air, is invariably ten degrees below the temperature of the surrounding atmosphere [not in winter?]. It is therefore one of those springs which lie so deep in the bowels of the earth, that it can neither be influenced by the scorching sun-beams in summer, nor by frost in winter."

"A large quantity of air bubbles are frequently seen to ascend from the bottom of the spring . . . and a thin column of steam generally hovers over the surface of the spring during the cool of the morning and evening."

"The water lines the stone reservoir at the part where the air touches the water, as well as the channel through which it flows with a yellow brown precipitate."

"The quantity of water afforded by the spring amounts to nineteen gallons in an hour.'

"The water . . . after having been exposed to the open air for a few hours become turbid . . . and in twenty-four hours a precipitate becomes deposited."

For his analysis of the water *see* p. 143.

"The ground about the spring was cleared . . . the spring was enclosed; a stone pavement laid round it; and in August 1818, the spring was opened to the free . . . use of the poor."

The medicinal characters are discussed at length.

At the end it is noted that "another Chalybeate Spring has been found at Thetford," but the site is not given. It "affords an abundant supply of water, which greatly resembles the original Thetford Chalybeate."

H. B. Woodward says, "The Spa at Thetford was probably the most important one in Norfolk: it was known and analyzed in the year 1746 by Matthew Manning. . . . The Spa House still remains, though the visitors have long since ceased to come." (1)

Wormegay.

According to H. Jones "there was a spring . . . just out of Setch (a name not on the one-inch maps, except in the form of the Setchy River) . . . to which people used to go some years ago . . . to drink the water." (2) The water presumably comes from Drift.

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(1) *Trans. Norfolk Nat. Soc.*, 1882, pp. 320, 321.
(2) H. B. Woodward, *Trans. Norfolk Nat. Soc.*, 1883, p. 526.

OCCURRENCES CONNECTED WITH UNDERGROUND WATER.

It is convenient to treat here of various subjects that are apparently dependent on underground water, chiefly in the Chalk, the last two of which are especially in evidence in Norfolk, whilst the first is common to all large tracts of Chalk.

Bournes, or Intermittent Streams.

In the broad Chalk-tracts of England the streams which rise in them and flow down the valleys are found to vary in their starting points. As a rule there is one spot below which there is always water, a permanent stream ; but above this we find an occasional stream, with varying points of outburst ; so that parts of valleys that are usually dry become channels of flowing water.

This is owing simply to changes in the level of the plane of saturation, or water-table. After wet seasons the underground water-level rises, until at length it reaches above the level of the valley-bottom, with the result of course that the water flows out, sometimes for several miles above the usual point of outflow, the distance varying with the amount of rain that has fallen.

The explanation is perfectly simple, and explains every occurrence of the sort. Consequently it is not always believed in even now. Of old so simple an explanation was of course not thought of, and various wonderful theories were propounded.

The subject has a large literature, and has been dealt with in detail in other Water Supply Memoirs, on the counties of Bucks. and Herts., of Hants., of Kent and of Surrey, and there is no need to say more of it now.

G. Barrow has said of a bourne in a northerly tributary of the Wissey (Geology of S.W. Norfolk, 1893), "At Drymere Pit, about two miles S.W. of Swaffham, water flows out after wet weather and a large covered drain has been made to carry off the water, which often used to flood the little valley in the rainy season. In summer however the outflow is lower down . . . near Shingham and Beachamwell."

The main springs of the Babingley River rise about half a mile above Flitcham Abbey ; but above this the stream is a bourne, water only running continuously after heavy rains have caused the underground water-level to rise. In February, 1883, I noted that the outflow started in a pool and wet ground below Massingham Station. Lower down the flow was discontinuous, whilst still lower it became nearly continuous, and then above the Flitcham springs, there were detached sheets of water. There was also water up the side-valley to the north, westward of Harpley.

H. B. Woodward writes that the valley along which the railway runs from Stanhoe Station to Burnham Westgate is always dry in the summer, but during the winter months a stream begins to run after the autumnal rains and flows through Burnham, continuing generally until May.

According to the same writer the Wensum is said to rise at Wicken Pond, on the border of Tattersett and Syderstone ; but after wet weather it rises at higher and higher levels, towards Barmer, according to the amount of the rainfall and the consequent saturation of the Chalk. At such times many small sheets of water or meres, occur here and there in the valley.

H. B. WOODWARD again says of the Burn (*see* p. 8). "In (after) wet weather, owing to the saturation of the Chalk, this stream rises at a higher level and forms pools and sheets of water south of Compton House."(1) The name Waterden, for a place a little eastward, is suggestive of a still higher outflow.

MERES.

Norfolk is notable for the many tracts of inland water that occur in it. The well-known Broads are the chief of these, and some of them have large areas. They occur along the river, and are broadenings of these. They have a literature of their own, and have been noticed in the Memoirs on the Norwich, Attleborough, and Yarmouth Maps.

We are not however concerned with these, but the smaller water-areas of the Meres are to a great extent connected with underground water. They occur chiefly in the wild heathy tract northward of Thetford, and have been described in some detail by F. J. BENNETT from whose account the following remarks are mostly taken.(2)

"They generally consist of small circular pools of water occupying crater-shaped hollows, with neither outlet nor inlet, and they are confined to that portion of the district where the Chalk comes to the surface, or where it is only very thinly covered by sandy drift."

"An examination of this heathy tract shows that the ground is pitted with a great number of these hollows, nearly all of which are dry at the bottom, though some of them contain water after much wet weather. At one time, no doubt, all these holes had water in them ; but as the country around was from time to time brought into cultivation and the land drained, the water-level in the Chalk, whence these Meres derive their supply, was lowered, and so most of them became dry."

The surface of the Chalk is much piped and "some of the pipes extend to a great depth and are filled with . . . sand, this being the locally prevailing drift over the Chalk. After a heavy rainfall the water would fill these pipes, passing down into [to] the water-level of the Chalk where they penetrated deeply enough, and enlarging the hole to that level by the dissolution of the Chalk. . . Again, as the water-level in the Chalk rose, so would the water ascend, rising through these pipes by preference, and falling, of course, as the level fell ; this rise and fall of the water through these pipes, acting chemically and mechanically, would enlarge them till the basins were formed."

(1) Geology of the Country around Fakenham, 1884, p. 1.
(2) The Geology of Attleborough &c. 1884, pp. 17–21.

"That these meres are all fed from springs from the Chalk at (about) the same water-level is probable from the fact that they are all at nearly the same height above the sea."

The Meres to which BENNETT alludes, as in the Chalk-tract, are Mickle Mere (in East and West Wretham), Hill Mere and Scot Mere (in West Wretham, all these being in Wretham Park), Fowl Mere (in West Wretham and Croxton), Home Mere and Punch-bowl Mere (both in West Wretham), Long Mere (Lang of the newer map, in East and West Wretham), Ring Mere (in East Wretham and Kilverstone) and Quiddenham Mere. It is curious that four of the nine are in two parishes.

Besides these there are some others, in the Boulder Clay-tract, which are caused by the partial damming up of the streams along which they occur. These of course have nothing to do with underground water.

In 1869 H. STEVENSON visited the three Meres of Wretham Heath, "which, from time immemorial, have been the natural watering places of the cattle and sheep depastured in that wild country; and which, like oases in the desert, delight the eye with their unlooked for and refreshing waters." He describes Ringmere, Langmere, and Foulmere. Of the first he says that "no less than seven parishes have the right of watering sheep" at it. In 1859 it was dry, "and a hole dug in the middle, about four feet deep, supplied no water," but two pits dug near by soon filled with water. "On the other hand, in some wet seasons, the waters of Ringmere have not only filled the basin, but have flowed over the road, till horses could stand knee deep, and then, flooding the level heath, have been known to extend themselves for nearly three miles, down to the Roudham houses (a clear case of a Bourne, *see* p. 37). In that same summer of 1859, Langmere was quite dry, and Foulmere consisted only of a small pond at the further end of the basin . . . ."

"In the hot summer of 1868, the waters were very low in all the three Meres, but never dry."

It has been said that these Meres have never covered so large an area since "the West Mere was drained, in 1851, and the Great Mere in 1859"; but he holds that they "have dried up from other causes than drainage." (1)

In 1903 we had an account of Ringmere, Langmere, Foulmere and the Devil's Punch Bowl by W. G. CLARKE,[2] with special reference to the question whether the Meres depend on overground or underground water. He says "The fact that three of the more northerly meres contained, when drained, traces of the pile-dwellings of prehistoric man, proves that these pools have not been formed during the historic period." He gives an account of the varying conditions of the four Meres and their water. It has been said "that the meres have been gradually getting dry since the well was made at the Thetford Waterworks in 1876. It has also been stated that there is most water in the meres in the driest summers. Facts prove that there is as little reason in these contentions as in the tradition which said that the price of corn rose with the waters of Ringmere," which was not the case. On the other hand, it can "be

(1) *Trans. Norfolk Nat. Soc.*, 1870, Vol. i, pt. i, pp. 36-41.
(2) *Trans. Norf. Nat. Soc.*, Vol. vii, pt. 4, pp. 499-511.

shown that the rainfall is solely responsible for the fluctuations of the water in the meres, not as surface water—or should ponds and wells on higher levels contain water when the meres are dry?—but so far as the rainfall affects the level of saturation in the Chalk." He gives an account of the rainfall over various periods, in one case showing "a maximum difference in the quinquennial periods of forty-seven inches . . . . and a minimum of thirty inches," which seems "sufficient to account for the remarkable fluctuations of the water in these meres . . . . It may also be noted that in 1882 when the meres were at their highest level for many years, the rainfall (of the county) was 33·34 inches, the highest yearly register for many decades." The paper ends with a table of the fluctuations of the four meres, up to 1902.

Perhaps the most striking of all the Meres is that described by F. J. Bennett in the Memoir on the Geology of the Country around Diss, 1884, as follows:—

"The Mere at Diss probably decided the situation of the town, which partly surrounds it. This expanse of water, which is oval in shape, is bounded on the north by steep shelving banks, while at one point on the south the margin is nearly level and has a communication with the Waveney, which, however, I believe to be an artificial one."

"The water is derived chiefly from springs in the Chalk, for although the Mere lies in the Glacial Sands, these sands are not very thick, so that its bottom, which lies deep down, must be on the Chalk."

A survey of 1835 makes the area 5 acres, 1 rood, 11½ poles, and the depth of the water (at the most) varied from 15 to 19½ feet. "But this did not include the depth of the mud, which must be considerable, the part of the town bordering the Mere having drained into it for a great number of years."

"An old analysis of the water showed the presence in it of chlorides of lime and sodium, and of carbonate of lime; while the mud was found to be impregnated with various substances, derived most likely from the sewage and other impurities originally carried into the Mere. No one now, however, is allowed to pollute it in this way."

J. E. Taylor has said, of the Norfolk Meres, "As a rule, they are situated on the upper boulder clays . . . They are not in connection with any rivers, and rarely with even small streams. They occupy the lower parts of the district, and are fed by small runnels during rainy weather. Hence they frequently dry up during a season of drought, their water supply being simply the storage of wet seasons. I do not think many of the Meres are fed by springs. If they were, the springs would have to issue from the drift sand which usually lie (lies) underneath the boulder clay, and I think a communication like this would be much more likely to let the water out, than to pour it in."

He regards Diss Mere as due to glacial action. ([1])

Mannington Mere is noticed further on, p. 42.

Subsidences.

This subject is allied to the foregoing, for many Meres owe their origin largely to subsidence. But many subsidences have not resulted in the formation of Meres.

([1]) *Trans. Norf. Nat. Soc.*, 1872, vol. i, pt. iii, pp. 38, 39.

We have records of the occurrence of subsidence of the ground in Norfolk, and these add to the probability of other hollows of which there is no record, or which were formed before records were invented, being due to a like cause.

According to information given to me by a farmer, in 1883, the strange hollows in the lower ground of East Walton, which have probably been caused by Chalk-springs, were known to increase; and he had noticed sinking of the ground after hot weather.

The tract between Walton Common and Gayton Thorpe Common is peculiar, being partly boggy, but with sandy mounds and roundish ponds, the latter surrounded by banks, like earth-works. These ponds seem to be due to the sinking of the beds, so that the surface has got to below saturation-level in the Chalk, and water consequently appears: they are in fact small Meres.

The Rev. D'A. Preston gave the Geological Survey the following particulars of a small but remarkable subsidence which occurred in August, 1879, on a farm in the parish of Rockland (?St. Peters or All Saints). The summer had been wet, and suddenly, with a noise as of thunder, the ground gave way, forming a deep shaft, up which water rushed, to 10 feet from the top. The hole was 30 feet deep: it gradually closed up to within 10 feet of the top, when it was filled up. The spot is on fairly high ground, on Boulder Clay, with patches of coarse gravel and sand. F. J. Bennett suggests that "just below the subsidence there may have been a nest of gravel or sand thinly covered by Boulder Clay; the water that filled the hole may have risen up this pipe and have washed out the sand and gravel, and the support being removed may have caused the roof of the hole to fall in." When he "saw it some time after the occurrence the hole was perfectly cylindrical and some 10 feet deep and 6 feet across, but there was no water in it."([1])

In treating of the country around Fakenham, Wells, and Holt (Maps 66, N.W. and S.W.) H. B. Woodward has said: "Owing to dissolution of the Chalk or Chalky Drift, subsidences of the ground have taken place at various times. But they may be in part due to other causes, as, for instance, where subterranean denudation, or removal of sand by springs, may have led to the falling in of small tracts of ground."

An instance which occurred two centuries ago in the parish of Mannington was recorded by P. Le Neve as follows:—([2])

On July 23rd, 1717, "in the Grounds . . . of Sir *Charles Petts* . . . in the day time, to the great astonishment of those that were present; first one single Oak, with the Roots and Ground about it, was seen to subside and sink into the Earth, and not long after, at about 40 Yards distance, two other Oaks that were contiguous, sank after the same manner, into a much larger Pit; being about 33 Foot Diameter, whereas the former is not fully 18 . . ."

"When the first Tree sunk, it was observed, that the Water boyl'd up in the Hole; but upon the sinking of the greater Pit, that Water drain'd off into it, from the former, which now continues dry. The depth thereof to the firm Bottom is nine Foot three Inches. . . . In the bottom of the greater pit, there is a Pool of

([1]) The Geology of the Country around Attleborough, etc., 1884, p. 21.
([2]) *Phil. Trans.*, 1718, vol. xxx., pp. 766–768.

Water about 8 Foot Diameter; whose Surface is 11 Foot 3 Inches below the Ground."

"The Soil on which these Trees grew, is Gravelly; but the Bottom is a Quick-sand over a Clay, upon which there are Springs, which feed large Ponds . . . at about a quarter of a Mile from these Holes."

"The Nature of the Soil seems to afford us a reasonable conjecture at the Cause of this odd accident. . . . The Springs running over the Clay at the bottom of a Bed of very minute (= fine) Sand . . . may reasonably be supposed in many Ages to have washt away the Sand, and to have thereby excavated a kind of Subterraneous Lake, over which these Trees grew: and the force of the Winds, on their Leaves and Branches, agitating their Roots, may well have loosened the Sand under them, and occasioned it to fall in, more frequently than elsewhere; whereby in length of time the thin Bed of Gravel being only left, it might become unable to support its own weight and that of the Trees it bore. That this is not a bare conjecture, may appear from the boyling up of the Water at first in the lesser Hole, and its standing in the bigger and lower."

In alluding to the subsidences at Mannington H. B. WOODWARD has said: "I was informed that Mannington Mere arose from a subsidence of the ground that took place in 1704." He adds that these subsidences "happened in a tract of ground where Glacial Sands rest on Glacial Marl."[1]

We have also another old record, by a MR. ARDERON,[2] who says that in the night (June 24th–25th) a violent thunder-storm occurred at and around Norwich, and that "at *Horseford* . . . about four Miles North-west of this City, a remarkable *Phœnomenon* appeared the next Day, the like whereof has not been observed in this County, since that communicated," as above.

"A sudden . . . Sinking down of the Earth, happened in this Village, in the Night above-mentioned, and left a Hole twelve Feet deep, and twelve and half in Diameter, in Form almost exactly round. Its sides are nearly perpendicular; and what seems most strange, no Ruffles, Cracks, or Chasms, are to be found nigh it, but the Ground appears intirely firm and solid; and for Miles about is a fine Champaign Country, of a dry sandy Soil, but not hilly; neither is there any Watercourse above Ground near it."

"The first Yard from the Surface downwards is Corn-mould Earth; the other three are composed of brown and yellow Sand, disposed in several different *Strata*."

"Might it not possibly be occasioned by some subterraneous Current washing away the sandy Matter by little and little, until it had left only a Crust, which the *Tremor* of this terrible Thunder had thrown down from the very Surface; though on this Conjecture, one would expect some Overflow or Appearance of Water; whereas I could not perceive here the Remains of a single Drop."

"At Bristan (Briston) . . . the neighbourhood were alarmed by a considerable sinking-in of the earth near the road, on Saturday the 21st of June (1788), in the night; but on the Sunday following, in

(1) *Trans. Norf. Nat. Soc.*, 1884, vol. iii., pt. v.
(2) *Phil. Trans.*, vol. xliii., pp. 527, 528.

the evening, a much larger sinking took place in a plough-field adjoining the road, the figure nearly circular, 210 feet in circumference, 60 feet in diameter, and in depth about 27 feet, with an irregular slope; upon examination, another falling-in was discovered about 90 feet in circumference; and all these without any agitation in the air, shock of earthquake, or the least subterranean noise. Holes have fallen in since, but none to produce a serious alarm." (1)

H. B. WOODWARD has said "These sinkings as well as those at Mannington, may have been partly aided by dissolution of the Chalk beneath the Glacial Drift."(2)

A. W. MORANT has given us the following record. "The farm at Whitlingham, upon which the sewage of Norwich is pumped, has for subsoil the sands forming . . . the Norwich Crag, which lies immediately upon the Chalk, having a depth . . . of 30 feet or 40 feet When the sewage was first allowed to flow over the land, we were astonished day by day to find the fields to be soon covered with circular holes, usually about 3 feet, 4 feet, or 5 feet in diameter and of various depths, the side always being vertical; on one occasion the ground suddenly subsided for a space of 21 feet in diameter and to a depth of 12 feet . . . and it appeared probable that the subsidence had taken place in these holes on account of the large quantity of water flowing over and working into the land so far in excess of any rainfall the soil had previously been exposed to."(3)

This is somewhat suggestive of possible pollution of water in the Chalk.

To conclude with another old record, for which I am indebted to G. W. LAMPLUGH (dated September 6th, 1793). "A spot of ground nearly 20 yards in circumference, of a circular form, yesterday, sunk to the depth of five feet, in the parish of Felmingham, Norfolk; and, on the day following, another chasm nine feet in depth, and of about the same extent and form as the aforementioned, was discovered in a field in the same parish. The earth is much cracked round the spots, but the parts settled are perfectly whole."(4)

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(1) *Gent. Mag.* 1788, vol. lviii, pt. ii, p. 649.
(2) *Trans. Norf. Nat. Soc.* 1884, vol. iii, pt. v.
(3) *Engineer*, vol. ii, p. 123. Quoted in the Norwich Memoir, 1881, pp. 139, 140.
(4) The Annual Register . . . for . . . 1793, pp. 40, 41.

CONTAMINATION AND RISK THEREOF.

General Remarks.

The protection of water from pollution is clearly so important that one is often surprised at things done that can hardly fail to affect the purity of water. Such errors in the past were owing mostly to ignorance or carelessness; but whilst in old times there was little knowledge on this subject, that excuse does not hold now. We have now a great accumulation of evidence in this matter; we have had outbreaks of disease clearly traced to contamination of water-supplies: we have been taught by experience.

It is useful then to collect together accounts of cases in our county in which examinations as to the risk of contamination have been made, so that by study of the past we may be armed to deal with the problems of the future.

In 1879 F. Sutton, the then County Analyst, wrote as follows: "During the past few years I have examined more than 1,500 specimens of Norfolk waters, and more than 1,000 of them had to be condemned as being unfit for drinking purposes owing to the presence of sewage matter. Of course, in many of these the examination was merely for health purposes, and extended only to the organic impurities and such of the mineral matters as might be the result of contamination. When I had the opportunity of tracing the character of the wells I have almost invariably found that those which had to be condemned were the shallow wells (in gravels and sands) . . . In some instances the waters have been found polluted in deep chalk wells, but here it is always the case that impure matter has been leaking into the upper part of the well from a cesspool or similar impurity situated in porous soil; in all such cases puddling the upper part of the well with clay has sufficed to get rid of the mischief." (1)

In December, 1911, Dr. J. T. C. Nash, in a Quarterly Report to the County Council said: "When wells and privies or cesspits are found within a few yards of each other in porous soil, and in such relative positions as ensures the gravitation of underground water from the cesspit towards the well, pollution is obviously possible, and in such cases chemical and bacteriological analysis merely serve to estimate the degree of pollution, or to strengthen the position of the Sanitary Authority in dealing with the matter The questions of water supply and sewage disposal are closely related. and cannot be considered apart."

Many incidental remarks on this subject have found a place in the accounts of wells, etc., as may be seen from the Index; but it seems well to treat separately of cases that have been more specially described, and these will be taken in their order of date, except that two references to the same place are put together.

It must be understood however that we are dealing with the past, and that in the present things may have improved, and in some cases the evil may have been got rid of.

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(1) *Proc. Norwich Geol. Soc.*, pt. iii., p. 88.

Local Cases.

Naturally for full accounts of these we are chiefly dependent on the valuable set of Reports made to the Local Government Board, to which the reader is referred for many details.

Swaffham.

In his Report to the General Board of Health, 1849, W. Lee noticed the dead wells in use for drainage-purposes, and showed how they were likely to result in the pollution of the water-wells from which the inhabitants got their supply. These dead wells varied from four to eight feet in diameter, and from 30 to 60 in depth, and it is said "that there are 45 of these immense dead wells in use in the town, besides others abandoned."

Since then a sewage-scheme has been established. The following note is connected therewith :—

The water used in the town is (or was) returned to the Chalk in the form of sewage, which is poured into an old chalk-pit on the eastern side of the road in the valley between Carol House and North Pickenham Warren, and about two miles S.S.E. of the waterworks.

I drew attention to this in 1886,[1] and said that luckily the sewage-pit seems not to be in the line of flow of underground water towards the town (and waterworks), and luckily it is some way from houses. As, however, we know little about the distance to which sewage in bulk may flow underground with retention of polluting power this experiment is of interest.

Norwich.

As a specimen of past conditions, and of what may be called, in the strict meaning of the term (not the chemical one), "previous sewage contamination," the following is interesting. The pages of the Report quoted from are 50, 51, 61 :—

In 1851 W. Lee reported to the General Board of Health that there were "10 public pumps ; and, although I do not here allege anything as to the quality of the water from them, it is a singular fact that five of them are situated adjoining to churchyards crowded with corpses."

He records also that "the private pumps in Norwich are of peculiar construction, being formed out of trunks, without casing.

He speaks too of a collection of 50 houses which "have no water but (from) the churchyard pump" (St. Augustine's), and notes that in one part "some wells have been turned into cesspools," and alludes to other delightful arrangements.

"It was stated that the city contained 1,000 public and private wells. . . The analysis of Mr. Dalrymple (*see* p. 159) proves to what a great extent the wells are polluted, and that the water is quite unfit for dietetic purposes."

"The result of my inspection, and the evidence, proves generally, that the city is almost entirely dependent upon a polluted river, polluted wells, and utterly inadequate public works for its supply of water."

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(1) *Trans. San. Inst.*, vol. viii.

Later on the water-supplies of various public institutions are condemned.

These things all occurred before the Company had started its supply.

In 1888 Dr. H. Airy said that in the suburban part of Catton parish "some wells were noticed in close relation with privies and cesspools," and in the list of households attacked with diphtheria in the northern outskirts most were served by independent pumps or wells, few having the city-supply.(1)

Hempton.

According to a letter from F. Coomber, in 1889, the water-supply of this village, got from surface-wells, was impure and unfit for domestic use. It had given rise to an epidemic of typhoid fever.

Lynn.

In 1892 there was an outbreak of typhoid fever in this town, and it was investigated by Dr. R. B. Low,(2) who referred its origin to the polluted water-supply. At that time the water was taken from the Gaywood River, some little way below the springs at the head thereof (*see* p. 30) and so it is really outside the scope of this Memoir, which deals with underground water; but I cannot help referring to it, as it seems so clear a case, and one to the possibility of which I drew attention more than eight years before the event, in an address to the Norwich Geological Society, delivered in 1883, and which Dr. Low did me the honour to quote.

Although this outbreak caused 16 fatal cases, it did not bring about a new water-supply, though enteric fever continued, and in October and November, 1897, there was a second epidemic, with 43 deaths, in Lynn and Gaywood, according to the Report of Dr. F. St. G. Mivart to the Local Government Board (No. 123, 1898).

He quotes from a MS. Report of my own (1892), as follows:—

"The southern, and apparently the most powerful, set of springs (of the Gaywood River) at Well Hall, seems to be looked on as the fit receptacle for all the filth of the farmyard. One building is directly over a spring, the water of which may be seen oozing out from under the outer wall. At the time of my visit a liberal allowance of muck, of which I did not care to make a minute examination, had been thrown down about as near as possible to others of the many springs here."

Dr. Mivart goes on to say "The above description depicts accurately the state of things at Well Hall at the time of my visit" (1897), and he notes other sources of pollution, which are "significant of the indifference of the population of the district to the purity of their water supply." This too was almost in defiance of a statement by eight medical men practising in Lynn, made in 1893.

Luckily these are now things of the past, as far as public water-supply is concerned, and the inhabitants of Lynn and part of its

(1) Report to the Local Government Board, No. 34. pp. 7–10

(2) Report to the Local Government Board, No. 63.

neighbourhood are now served with a pure supply of water, from a well in the parish of Gayton (*see* p. 87).

Loddon.

Before 1895 the town seems to have been free from enteric fever; but in that year there was an outbreak, which was reported on by Dr. S. M. COPEMAN (Local Government Board, No. 95), whose description of the water-supply is given on p. 99.

He says that "suspicion had arisen as to the water of the town pump having some concern in the spread of enteric fever in the place," and this seems to have been justified, for "in by far the greater number of invaded households it was from the town pump that the water-supply had been obtained." Moreover "with very few exceptions, the houses in Loddon invaded by the disease are in close proximity to the Green, in the centre of which the town pump stands."

The use of this well was stopped, the handle of the pump being chained up, and "it is of interest to observe that, with a single exception, the disease had completely died out within three weeks of the supply coming practically to an end, and within less than a fortnight of the pump being chained up . . . so that . . . it would appear not improbable that the disuse of the water-suppy afforded by the town pump and the cessation of the disease may have stood the relation to each other of cause and effect."

32 cases of fever were notified, of which no less than 8 were fatal.

An experiment was made to see if the supply from the town-pump could be improved, "the well was opened out, cleansed, 'bottom-fied,' and the water pumped out repeatedly, after which a supply of lime was put into the well. While these operations were in progress a large 'soakage' well was discovered at a distance of about 5 yards from the pump well . . . This soakage well was apparently between 8 and 9 feet deep, but on investigation it was found that there existed a further depth of about 15 feet, which was filled up by black mud, the bottom of which was, roughly speaking, on a level with the surface-water in the pump well. No direct overflow from the soakage well had been provided, so that as neither well was steined it is very probable that a quantity of fluid material found its way through the intervening soil from the soakage well to that in connection with the town pump. In consequence of this supposition the mud was removed from the soakage well, some lime was placed at the bottom, and the whole filled in with soil . . Afterwards water was again pumped more or less continuously from the well for some time, after which the second specimen was taken for chemical analysis (*see* p. 157). The result of such analysis, however, showed that the water was as unfit as ever for drinking purposes, and therefore the pump has remained chained up . . . to prevent its further use."

North Walsham.

The old state of things, before the establishment of the waterworks, have been described in a Report to the Urban District Council by J. C. MELLISS, from which the following remarks are taken (*Downham Market Gazette*, 2nd Nov. 1895).

"The present water supply is obtained from shallow wells, of which there are about 171 in the town itself; there is no other supply, and these wells all derive their water from sand and gravel formations. Such a water supply has no doubt answered its purposes in the past, and might be continued. . . . if the ground from which the water is taken had remained unpolluted, but unfortunately this is not the case; the primitive privy and cess-pit system, together with the close proximity of burial-grounds, in an open porous soil such as that at North Walsham, has been so long in use that the subsoil has become contaminated and the water which flows through it is rendered quite unsafe for domestic purposes. The evidence on this point is . . . . sufficient and conclusive." The results of various analyses all "point to a serious contamination and condemnation of the present water supply. Experience has shown that when contamination of the soil and a water supply takes place, such as has occurred at North Walsham, though it may be practicable to remove the primary cause of pollution by the abolition of the cess-pits, &c., it is not possible to purify the soil which has been polluted, nor will it return to anything like a state of purity for very many years."

Fincham.

In 1906 Dr. R. Farrar reported to the Local Government Board (No. 238) on an outbreak of enteric fever at this village, and he says "Water is obtained from wells of moderate depth, 20 feet or so, sunk in the Chalk (through Drift). Several of these wells are liable to contamination from soakage," and many of the cases seem to have been connected with the water of a polluted well in Banyard's Yard, in some cases indirectly, through milk. For analysis of this and other waters, *see* pp. 151, 152.

Heacham and other Coast Villages.

In treating of this part of the Docking Rural District Dr. W. W. E. Fletcher[1] says that except for the small part supplied from the Hunstanton Waterworks, water is mostly got from wells, which "are of the character of surface wells, usually dry steined with bricks or stone, or cut through the solid chalk," generally without any attempt at close fitting. The depth of (? to) the water below the ground surface varies from 4 . . . to 40 feet . . . in different parts . . . according to the elevation above sea-level, but the deepest wells observed, those at Sedgford, do not appear to reach a depth of 50 feet. The sites of the wells are almost invariably unsatisfactory, and the water is in consequence exposed to many possible sources of pollution."

Heacham was the worst village. A report by E. J. Silcock is quoted, and from it the following remarks are taken, from which it appears that the water-supply "is entirely derived from shallow wells . . . sunk into the sand and gravel . . . or into the lower greensand." These beds being porous and the drainage being by cesspools of dry brickwork with open joints, "it is only reasonable to expect

[1] Report to the Local Government Board, 1907, No. 294.

that the subsoil . . . would be polluted, and that the wells would be contaminated."

A list of 24 wells offending is given by DR. FLETCHER, who adds "These two dozen specimens may suffice to demonstrate the highly unsatisfactory state of affairs with respect to water-supplies."

According to the Local Government Board Return of 1915 the supply is now taken in bulk from the Hunstanton Works.

The following are the numbers of offending wells noticed at the various parishes:—Dersingham 8, Snettisham 5, Holme 7, Thornham 3, Titchwell 1, Brancaster and Brancaster Staithe 15, Burnham Deepdale 2, Burnham Norton 3, Burnham Overy (at Overy Staithe) 6, Sedgeford 5 ?

The conclusion is "It is clear that, as regards water-supplies, the villages mentioned, excepting, possibly, Sedgeford, are in a deplorable condition."

A table of analyses of the waters of 44 wells is given, for particulars of which see under the various villages in ANALYSES.

Wells.

In reporting to the Local Government Board on the General Sanitary Circumstances in the Wells Urban District, DR. S. M. COPEMAN writes, "In his Annual Report for 1912, the Medical Officer of Health states that the water supply is plentiful and good, adding that 'no complaints of pollution have been made.' But in view of the fact that the water supply is entirely derived from surface wells, in some instances, within a few yards of privies and cesspools, it would be somewhat remarkable if pollution did not occur from time to time, even though no complaint is made. And, as a matter of fact, I heard of several complaints as to the water having an unpleasant taste and smell. Certain of the wells in the lower part of the town near the Quay are liable to be invaded by sea water at such times as specially high tides are experienced, so that the drinking water becomes unpleasantly brackish."

"The only analyses of drinking water available were made by the County Analyst (Mr. Sutton) in July 1909, and July 1911 . . . but . . . there is no record to show whence the samples of water were taken. Commenting on the most recent of these analyses, Mr. Sutton says that the figures for nitrates, as well as chlorides, are enormously high, adding that the surrounding soil is evidently subject to such serious pollution by animal impurities as to render the water quite unsafe for drinking purposes."

Of three analyses of water from wells, made by the Clinical Research Association (? in 1914) two showed no trace of pollution, but the third (Church Room water) was badly polluted.

Nothing seems to have been done, however, and in his Annual Report to the County Council for 1914 DR. J. T. C. NASH alludes to the subject (*see* p. 129).

Witchingham, Great.

The following remarks are from a report of a meeting of the St. Faith's District Council, in the *Eastern Daily Press* of November 27th, 1908.

Dr. Long, the Medical Officer, noted the occurrence of several cases of diphtheria in the hamlet of Lenwade and reported that the supply of drinking water was got from wells scattered through the village. The level of the water in these varies from a few feet to about 30 feet down. There are almost as many cesspools as wells.

Mr. Sutton condemned the water of four wells.

F. W. Harmer, the well-known Norfolk geologist, made a report on the subject, from which I quote.

"The conditions under which that village (Lenwade) is supplied with water are unsatisfactory to the highest degree. As water can be found everywhere at the same actual level, and generally a few feet only below the surface, the wells are naturally very shallow. There is probably but little difference between the level at which the surplus water escapes from the cesspools and that at which, a few yards distant, it is drawn from the wells for drinking. Moreover some part at least of the water taken from the latter for household purposes must find its way into the cesspools, from which, mixed with sewage, it may eventually pass into the porous gravel and, by percolation, into the wells." The contents of the privy-pails as a rule are dug into the gardens. "Considering the permanently wet condition of the subsoil, however, and the shallowness of the wells, this cannot be unattended with danger. Under these circumstances we might expect to find that in all parts of Lenwade the wells are contaminated with sewage," a view supported by Mr. Sutton's analyses.

MISCELLANEOUS.

There are a few notes which do not conveniently fall under any of the headings above, and which can be best grouped together here.

RAINFALL.

We have an almost continuous record of the rainfall in the county for more than forty years, from 1874 onwards, and for South Norfolk this is absolutely continuous from 1839 to 1888.

The work for the whole county is due to two observers, J. QUINTON and A. W. PRESTON, the latter of whom carried on the record from 1883 to 1916.

All this long set of observations is recorded in the Transactions of the Norfolk and Norwich Naturalists' Society, to which the reader is referred for details. The following is an account of the changes in the method of publishing the results.

In 1874 the Society began to publish records of rainfall, in "Notes on the Meteorological Observations Recorded at Norwich during the years 1870 to 1873," [a] by JOHN QUINTON, in which the figures are given for the winter, spring, summer and autumn quarters, without further detail.

In the continuation of this work for 1874, the table is given for months, and it goes on so for 1875–1879. [b] Mr. QUINTON'S communications then ceased; but A. W. PRESTON took up the work, under the title "Meteorological Notes," in practically the same form, for 1883, 1884, giving the localities of Thorpe Hamlet (Norwich) and Heigham, for 1885–1887, but the former only for 1888. [c]

We also have "Observations on Rainfall" by F. DIX, in which he gives a table of "Fifty Years Rainfall in South Norfolk, 1839 to 1888 . . . 35¾ years at Dickleburgh, 14¼ years at Norwich." [d]

A. W. PRESTON'S work continued, on much the same lines as before, for the years 1889–1916, by seasons and by months.

His Notes for 1889–1892 are from observations at Blofield. Those for 1893 from observations at Blofield and Brundall. Those for 1894–1904 from observations at Bradestone House, Brundall. Those for 1906–1916 from observation at Norwich.(1)

In the Presidential Address (Vol. vi, pt. 4, 1898, p. 344) there is a table of monthly and annual rainfall from 1888–1897.

F. DIX contributed a paper on "Nineteenth Century Rainfall" referring to the East of England.(2)

A. W. PRESTON also wrote "Notes on the great Norfolk Rainstorm of 25th and 26th August, 1912.(3)

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[a] *Trans. Norf. Nat. Soc.*, vol. i, pt. v, 1874 ? pp. 71-79, folding table.
[b] *Ibid.*, vol. ii, pts. i–v (1875–1879), vol. iii, pt. i (1880).
[c] *Ibid.*, vol. iii, pt. v (1884), vol. iv, pts. i–v (1885–1889).
[d] *Ibid.*, 1889, vol. iv, pt. v, pp. 676, 677.

(1) *Ibid.* Vol. v. pts. i—v (1890–1894), vol. vi, pts. i—5 (1895–1899), Vol. vii, pts. 1—5 (1900–1904), Vol. viii. pts. i—v (1905–1909), Vol. ix, pts. i—v (1910–1914), Vol. x, pts. i—iii (1915–1918).
(2) *Ibid.* 1901, Vol. vii, pt. 2, pp. 260, 261.
(3) *Ibid* Vol. ix, pt. iv, p. 551 and rainfall-map. 1913.

Pumping Interference.

In 1870 J. E. Taylor and A. W. Morant, observed the excavations made for sewerage in Norwich, and recorded one of the results as follows :—

"During the progress of the sewerage works, several pumping-engines have been working night and day, lifting about 17,000,000 gallons of water in each twenty-four hours. The wells for two miles round Norwich have mostly been drained, although the river, which flows through the middle of the drained area, has been unaffected. The wells sunk in the solid undisturbed Chalk, were those first affected; the wells situated in the re-deposited Chalk (which they note as of general occurrence at the top of the formation) . . being so in a less degree. Wells on the higher grounds, sunk through the sand and gravel, have been untouched, especially if they had a bottom of brick-earth." (1)

A letter from W. Matthews, of March, 1896, says that the Well Hall Spring at Gayton (*see* p. 31), has nearly ceased to flow owing to the pumping at the new well (*see* p. 87) which seemed to be discharging over three quarters of a million gallons a day. At the same time the Union well had been very little affected.

Blowing Wells.

In 1909 Dr. S. H. Long noticed three wells about three miles from Norwich, and about 140 feet above sea-level; and two years later he gave the following account to the Norfolk Naturalists Soc.(2)

"In the village of Framingham Pigot . . there are three examples of what are known as 'blowing' wells . . Two of the wells are in the grounds of the Manor House, about 300 yards apart; the third is in the village street, about 100 yards from one of the other two. All three wells are domed over, and in the case of one, which was originally domed without the insertion of a ventilation-pipe, the dome was blown off by the pressure of air within the well."

"Repeated observations, by myself and others, have shown that air is sometimes being forced out of the well and at other times sucked in; and in . . one well, where a grating is fixed over the end of the ventilation-shaft the sound produced by the air vibrating against this is at times so loud that the well is then said to roar, and can be heard at a distance of several yards. It is commonly held by the inhabitants of the village that the intensity of the roaring of this well permits of an accurate forecast of the state of the weather. Observations show that this tradition . . rests upon a scientific basis of fact."

There is "a correlation between . . barometric changes of pressure and the entry and exit of air through the ventilation pipe." This

(1) *Geol. Mag.* Vol. vii. p, 121.
(2) *Nature*, Vol. 80, No. 2064, p. 339., and *Trans. Norf. Nat. Soc.* 1911, Vol ix, pt. ii, pp. 191, 192.

has not been measured "but ordinary methods of observation have demonstrated that with a fall in the barometer the well 'blows' out, and when the barometer is rising it is invariably 'sucking' in."

In 1885 C. B. PLOWRIGHT concluded, from his investigation of the distribution of stone in the bladder in Norfolk, that most cases occurred on the Norwich Crag and gravels and sands of the Drift whilst on clay cases were fewest. In those rivers outlined by Crag, the cases followed their course remarkably. Presumably this is connected with water.

In 1899, SIR S. F. HARMER recorded the occurrence of the well-shrimp, *Niphargus* in the well at his father's house, at Cringleford, the well (then about 25 years old) being 40 feet deep, in chalk, overlain by 2 or 3 feet of humus. This is the first record of the animal in East Anglia.

Trans. Norf. Nat. Soc. vol. vi, pt. 5, p. 489.

SUPPLIES FROM SPRINGS.

Several supplies are taken from springs, mostly for small places; but in one case a large supply has been taken from a Chalk-spring, mostly for places outside Norfolk, including the towns of Wisbech and March, and this notable case of spring-supply is a good instance of one county supplying another with water, under the management of a Company.

It is perhaps strange that use is not made of more of the many springs of the county, care being taken to safeguard them from pollution.

The following notes are arranged in the alphabetical order of the places.

Castle Rising.

Ordnance Map 145, new ser. (Norfolk 22, S.E.). Geologic Map 69.

Spring at gravel-pits. Supplies part of North Wootton.

Quantity ample. Quality very good.

Dersingham and Flitcham.

Ordnance Maps 145, 146, new ser. (Norfolk 23, N.W. and S.W.). Geologic Map 69.

According to the Local Government Board Return of 1915, p. 293, parts of Sandringham, West Newton and Wolferton, are supplied by the King.

1. By a spring from Chalk, in the parish of Flitcham, *see* p. 32.
2. By a spring from carstone and sand at Jocelyn's Wood (Dersingham).

Quantity ample. Quality very good.

Holt.

Ordnance Map 131, new ser. (Norfolk 10, S.W. and 18 N.W.). Geologic Map 68 S.W.

According to the Memoir on the Geology of the country around Holt (1884), from which these notes are taken, the water-supply had been mostly obtained from the spring called "the Spouts" that issues to the south-west of the town at a spot called Spout Hill, at the junction of the Glacial sands and gravels with the brick-earth and marl beneath. This has been advertised as "the purest water in England," and as an Artesian Well; it is, however, an ordinary land-spring.

From this spring most of the inhabitants have been supplied, the water being carried to various houses in the town by tub-carts and buckets.

The copiousness of the spring is no doubt due to its receiving the drainage of a considerable tract, although the direction and extent of its numerous sources cannot be determined from any surface-evidence. The irregularities and local inclination of the beds might allow the waters that fall on the brow of Kelling Heath on the north, to flow southward in devious subterranean courses to help to swell the Holt spring. Issuing as the spring does from immediately beneath the town of Holt, it is of course particularly liable to contamination from the leakage of cess-pits, &c., in the town; and this is reported to have been the case.

There were few private wells, but there were two pumps about 50 feet deep which helped to supply the houses. Now, however, the supply is largely from well (*see* p. 95).

Hunstanton.

Ordnance Map, 129, new ser. (Norf. 5, N.E. and S.E.) Geologic Map, 69.

New Hunstanton Urban District Council.
From the Local Government Board Return of 1915, p. 97.

Springs from Chalk at Old Hunstanton.
Average daily supply 77,600 gallons and 6,000 in bulk, total 83,600.

Supplies also, in bulk, to Docking Rural District Council (for Heacham).

Water of exceptional organic purity (1911). Hardness, total 15·9°, permanent 4·7°. Acts on lead, but lead pipes are not used.

According to a communication from H. A. READ, of 1908, the works were bought from a Company, in 1897. The copious and constant springs are from the base of the Chalk N.E. of the old village, and about 30 feet above Ordnance Datum. About 9 hours pumping a day yielded 180,000 to 200,000 gallons.

DR. J. T. C. NASH noted, in April, 1909, that three weeks after times of drought or of heavy rain, a decrease or increase in the yield was noticeable. In that year the average daily consumption was 110,000 gallons = 50 a head per day.

Population supplied, in 1911, 1,725.

Kelling.

According to the Reports of the Medical Officer of the Erpingham Rural District, 1913, 1914, this village "is supplied by water laid on from a spring in the neighbouring hills."

Sheringham, *see* under Wells, pp. 118, 119.

Wisbech.

This Cambridgeshire town takes its water-supply from Norfolk, and supplies also another town in the former county, March. Powerful springs at Marham are the source (*see* p. 30) and the supply is notable amongst the spring-supplies of the country, the weekly average yield being 5,138,160 gallons, besides 50,000 given in bulk. By mistake this is given as the daily average in the Local Government Board Return of 1915, p. 228.

A supply of nearly three quarters of a million gallons a day wholly from springs at one spot is unusual. Had it not been for these springs it is hard to see how the two Cambridgeshire towns could have been properly supplied, and this is a case showing the futility of county-boundaries in the matter of water-supply.

Although the water was originally taken for supply in Cambridgeshire, as the mains on their way to Wisbech are chiefly in Norfolk, a supply is also given to the following places in the latter county (according to the Local Government Return): Bexwell, Crimplesham, Denver, Downham Market (part), Emneth, Fincham, Fordham, Hilgay, Marham, Runcton Holme, Ryston, Setchey, Shouldham, Shouldham Thorpe, South Runcton, Stow Bardolph, Stradsett, Terrington St. John, Tilney (St. Lawrence, and with Islington), Tottenhill, Upwell, Wallington, Walpole St. Peter, Walsoken, Watlington, West Downham, Wiggenhall (St. German, St. Mary Magdalen, and St. Mary the Virgin), Wimbotsham, Wormegay.

SUPPLIES FROM WELLS.

Like the rest of the South-Eastern counties, Norfolk gets its water from wells far more than from any other source; but it differs from them in that its largest two supplies (for Norwich and Yarmouth) are got from rivers and therefore there is no very large well-supply in the county, that of Lynn being the largest (866,000 gallons a day) and that is only a little more than that taken from the springs at Marham, for Wisbech, etc. There is no well-supply reaching up to a million gallons a day; only one, that of Lynn, reaches to a quarter of a million, and only one other (Cromer) reaches even a hundred thousand. It is clear then that Norfolk is a county with many small well-supplies.

There are, however, many supplies for factories, etc., of fair size, and it is in these only that borings have been made to a depth of 500 feet or more, so that all our information as to the deeper seated geology of Norfolk is got from this source.

There is only one boring that reaches a depth of 1,000 feet, at Norwich (Colman's) and that is nearly 1,200 feet deep. One other, at Holkham, is over 700 feet deep. Three others (at Diss, Lynn and Norwich) reach below 600 feet, and yet three more (at Norwich and Yarmouth) reach to 500 feet or more.

The deepest borings for Waterworks are for Cromer and Diss, neither reaching 500 feet.

The following wells are of notable geologic interest:—

Baconsthorpe and *Blo' Norton*, great thickness of Drift; *Broome*, section through Drift and Norwich Crag; *Cantley*, deep Drift, or possible London Clay; *Cley*, deep Drift; *Congham*, deep channel of Drift; *Cromer* (Waterworks), through Drift and Pliocene beds into Chalk; *Forncett*, deep Drift; *Gayton*, small thickness of Gault; *Langley* and *Great Massingham*, deep Drift; *Melton Constable*, great thickness of Drift; *Merton* (Broomhill Farm), deep channel of Drift; *Metton* and *Mundesley*, sections through Drift, Forest Bed and Crag; *Needham*, through Drift and Norwich Crag; *Northrepps*, great thickness of Drift; *Norwich* (Colman's), through Chalk and Upper Greensand into Gault; *Roughton* (two), great thickness of Drift; *Saham Toney*, borings show deep channel of Drift; *Shotesham All Saints*, deep Drift; *Southwood*, deep Drift, or possible London Clay; *Stody*, deep Drift; *North Walsham* (Waterworks), section through Drift and Crag into Chalk; *Wheatacre*, great thickness of Norwich Crag Series.

The following Waterworks wells are of interest in the matter of supply, besides some of the private supplies, notably at Norwich:—

Cromer, *East Dereham*, *Diss*, *Gayton* (for Lynn), *Metton* and *Roughton* (for Cromer?), *Sheringham*, *Swaffham*, *Thetford*, *and North Walsham.*

The following wells are believed to be new, sometimes in the sense that details of them have not been published before, besides a number of others of a shallow kind or of small interest.

Baconsthorpe, East Bilney, Old Buckenham (the Hall), Cantley, Cawston, Cley, Congham, Crimplesham, Cromer (Gas Co.), Dersingham, Diss (Waterworks and Aldrich's), Ditchingham (No. 5), Forncett, Garboldisham (Uphill Farm), Gayton, Guist, Harleston (Robinson's), Hillington, Hockwold, Holt (Nos. 4, 5), Honingham (two), Ingham, Langley, East Lexham, Great Massingham, Melton Constable, Middleton, Northrepps (the Hall), Norwich (Colman's later well, Mousehold Heath barracks and prison), Rockland (Kirk Hall Farm), Roudham, Roughton (two), Rushall (No. 3), Rushford, Sandringham (No. 2), Sheringham (Waterworks), Shotesham All Saints, Southwood, Stibbard (Sennowe Hall), Stody, Swanington, Thorpe, Wheatacre (Hall Farm), Woodbastwick, Wretham, Wymondham (Vicar St.)

DETAILS OF WELLS AND BORINGS FOR WATER.

In compiling this account of the wells of Norfolk published matter has been laid under contribution fairly exhaustively, and it has been supplemented by information kindly given by authorities and companies, by engineers and well-sinkers, by owners of works and of houses, and by various observers, due acknowledgment being made under each case.

The arrangement followed is an alphabetic one, according to the names of the places or parishes in which the wells are placed, these names being given as a heading, in thick type. Cross-references and the Index serve to clear up doubtful points.

Some general remarks, on the neighbourhood of East Dereham, are given first.

The following information is from a map sent me by B. LATHAM, who was consulted about a new water-supply for East Dereham. It was drawn up from this by J. H. BLAKE, for the Memoir on the Geology of East Dereham (1888).

LIST of WELLS in the neighbourhood of East Dereham, showing Surface-levels and Water-levels in feet above Ordnance Datum.

Parish.	Site of Well.	Above Ordnance Datum.		Depth of Water below Surface.
		Surface-level.	Water-level.	
Beeston ...	Tile-kiln, 1 mile N. by E. of church	201·16	163·66	37·5
	Newhouse, 1⅜ mile N.E. of church	189·11	166·81	22·3
	Near stream, nearly ¼ mile E. of above well	216·96	167·48	49·48
Dillington ...	⅜ mile W. of Dillington House ...	129·41	117·44	11·97
East Dereham	N. of Toft Wood Mill, on eastern side of road, 1⅜ mile S. of church	161·97	147·97	14
	W. of South Green, ⅞ mile S. by E. of church	162·08	147·03	15·05
	⅜ mile S. by E. of church ...	167·99	146·49	21·5
	⅛ mile E. of railway-station, on southern side of road	175·09	152·09	23
	Nearly ¾ mile E. of railway-station, N. of mill	176·29	161·29	15
	Etling Green, 1¼ miles E. by N. of railway-station	181·49	146·65	34·84
	⅛ mile N.W. of church	130·45	129·35	1·1
	½ mile N.E. of church	179·18	149·18	30
	A little more than 1½ miles N.E. of church, on eastern side of road	203·24	151·24	52
Gressenhall...	N.E. corner of Buckstone Wood, and ½ mile N. of church ...	139·44	128·14	11·3
	Nearly ¾ mile N. by E. of church	120·06	109·96	10·1
	Nearly ½ mile E.S.E. of church ...	105·87	102·17	3·7

Parish.	Site of Well.	Above Ordnance Datum.		Depth of Water below Surface.
		Surface-level.	Water-level.	
Litcham ...	Chalk pit, $\frac{1}{8}$ mile E.N.E. of church	179·08	?	?
	Near stream, $\frac{1}{4}$ mile S.E. of church	155·29	152·09	3·2
Little Fransham.	$\frac{3}{16}$ mile S.S.E. of church, on northern side of road	217·99	207·39	10·6
Longham ...	Near stream, S. of Ostrich Inn and $\frac{5}{8}$ mile E. by S. of church ...	189·54	168·64	20·9
North Tuddenham.	$1\frac{3}{8}$ mile N.W. by W. of church, on northern side of Norwich road	137·67	134·87	2·8
	$\frac{3}{8}$ mile N.W. by W. of church on northern side of road	131·56	124·41	7·15
Scarning ...	$\frac{5}{8}$ mile W. of church, on northern side of road	190·98	181·48	9·5
	Close to, and S.E. of church, on southern side of road	209·6	188·3	21·3
	$\frac{5}{8}$ mile E.N.E. of church	161·91	154·18	7·73
Shipdham ...	$\frac{3}{8}$ mile N.E. by E. of church, on northern side of main road ...	231·36	222·49	8·87
	$\frac{7}{8}$ mile E.N.E. of church, on southern side of road	222·35	215·15	7·2
	Thorpe Row, northern side, $1\frac{1}{4}$ mile N.E. of church	253·78	253·78	0
	Near Lolly Moor, $2\frac{1}{2}$ miles N.E. of church, on western side of main road	166·09	166·09	0
Swanton Morley.	$1\frac{1}{8}$ mile S. by W. of church, on eastern side of road	194·72	148·22	46·5
	Cherry Ground, W. of road, $\frac{3}{4}$ mile S.W. by S. of church	189·24	147·04	42·2
	N. of Greengate, W. of road, $\frac{1}{2}$ mile S.W. by S. of church	173·46	127·26	46·2
Wendling ...	A little more than $\frac{1}{4}$ mile S.W. of church	182·82	175·18	7·64

Mr. Baldwin Latham says that "the subterranean water, as ascertained by wells sunk in the Boulder Clay at East Dereham, Norfolk, showed that the [slope of the] water-level varied from 2 feet in a mile in the flat tableland to 100 feet in a mile in the valleys." *Rep. Brit. Assoc.* 1876, *Sections*, p. 227 (1877).

The following levels above Ordnance Datum were also obtained by Mr. Latham :—

	Feet.
Swanton Morley.—Surface of water of River Wensum, $\frac{1}{4}$ mile N.E. of church	61·39
Surface of Chalk, about $\frac{1}{8}$ mile N.E. of church ...	79·47
" " " ...	75·63
Springs in Chalk " " ...	75·00
" " " ...	72·00
North Tuddenham.—Surface of water of tributary of River Wensum, $\frac{1}{4}$ mile S.W. of church	100·32

Attleborough.

Ordnance Maps 161, 175 new ser. (Norfolk 85, S.E.). Geologic Map 66, S.W.

1. Temple Hill House.

Made and communicated by Messrs. GIDNEY.

Shaft 10 feet, the rest bored.

		Thickness feet.	Depth feet.
	Made soil	3	—
[Glacial Drift]	Light-coloured clay	4	—
	Stone	10	—
	Gravel	12	—
	Blue clay with flints	155	184
[Upper]	Chalk and flints	14	198

Nos. 2, 3 sunk and communicated by POOLEY. No 5 by LINCOLN.

2. Mr. Ketteringham's brickyard.

Loam	10	67 feet
Sand	7	
Boulder Clay, to Black Clay	50	

3. Opposite Corn Hall. Water unfit to drink.

Gravel	5	19 feet.
Red sand	14	

4. Near the Baptist Chapel.

Gravel	5	19 feet.
Sand	4	
Boulder Clay	10	

5. Station Road, northern end, first house.

Gravel	10	13 feet.
Loam, to gravel and water	3	

Wells in Boulder Clay, sunk and communicated by LINCOLN.

6. A mile south of the church. Good supply of water. 44 feet.
7. Sixth house from northern end of Station Road. Water rose to the surface. 44 feet.
8. King's Head Inn. 60 feet.

Wells through Boulder Clay, etc., sunk and communicated by LINCOLN.

9. Second house from northern end of Station Road.

Boulder Clay, to gravel and water, 18 feet.

10. Mr. Long's, south of the station. Boulder Clay to sand and water, 20 feet.
11. Connaught Road, brickearth to gravel, 15 feet.

Wells in Gravel, etc., sunk and communicated by LINCOLN.

12. Royal Hotel. Gravel, 9 feet.
13. Cottage south of station. Sand and gravel, 12 feet.
14. Connaught Road. Gravel, 11 feet.
15. Point House (source uncertain). Gravel, 12 feet.

Wells through Gravel to Boulder Clay.

16. Royal Hotel (another well). Gravel, 5 feet. Boulder Clay 7.
17. Kent House, London Road. Gravel, 6 feet. Boulder Clay to sand, 2.
18. Further south than the last. Gravel, 4 feet. Boulder Clay, 35.

Aylsham.

Ordnance Map 147, new ser. (Norfolk 28, S.E.). Geologic Map 68 E.

1. Railway station [? the one S.E. of the town].

Recorded by C. REID (before 1882).

Well sunk 25 feet through sandy brickearth. Water got at the depth of 18 feet

2. A temporary well, about half a mile west of the station.

Glacial Drift	Sand	10	27 feet.
	Brickearth and sand ...	10	
	Blue clay	7	

3. ? Soame Memorial Well; Carr's Corner, at junction of Cawston and Blickling Roads. From DR. NASH.

150 feet deep. Yields a copious supply. For analysis of the water, *see* p. 144.

Of the Rural District it was said in 1913, by the Medical Officer, that there is no public supply, that some of the private wells are deep, with good water, whilst others get surface-water and are subject to pollution. In a paper at the Local Government Board it is said that the quality of the water generally throughout the district is good, and the supply adequate, but there are cottages and groups of cottages which have no supply of wholesome water within a convenient distance.

Baconsthorpe.

Ordnance Map 131, new ser. (Norfolk 18, N.E.). Geologic Map 68, S.W.

Made and communicated by MR. R. RICHARDS.

Water rose to 68 feet below the surface.

		Thickness feet.	Depth feet.
Dug well, the rest bored		—	50
[Glacial Drift]	Silt and pebbles	3	—
	White marl	4	—
	Sand and pebbles	55	—
	Brown clay	2	—
	White marl	98	212
[? Drift and Crag]	Grey sand...	66	278
Chalk, very rotten.	Had to be lined with perforated tubes	94	372

Bacton.

Ordnance Maps 132, 148, new ser. (Norfolk 20, S.E.). Geologic Map 68, E.

W. FAKE, of Norwich, writes in 1907 of a well 45 feet deep at a small boarding-house on the coast (? S.E. of the village, in Drift), the water of which was brackish, and said that it was a bad district for water, as that of most wells was brackish. A tube-well was driven into the chalk in 1899 ?; but I have not been able to find any further record.

Banningham.

Ordnance Map 147, new ser. (Norfolk 28, N.E. and S.E.). Geologic Map 68, E.

New Farmhouse (1879), on the Aylsham road, half a mile southward of the church.

Recorded by C. REID.

Loamy soil		1 to 2	? 19 feet.
Glacial Drift	Sand	13	
	Loam	4 to 5	

Barnham Broom.

Ordnance Map 161, new ser. (Norfolk 62, S.E.). Geologic Map 66, N.W.

In 1894 Dr. T. W. THOMPSON said of the water that it "is obtained from wells sunk, in some cases to a depth of 60 or 70 feet, into the clay . . Internally they are dry steined with brick," and, therefore, "they are liable to admit water from the superficial layers of the soil, and in one or two instances such water was seen trickling into them. They are thus, of course, exposed to danger of pollution, and . . . chemical analysis has recently shown certain of them to be polluted. Thus, all the three wells by which Pockthorpe has hitherto been supplied have been condemned by the county analyst as being polluted with sewage, and at the time of my visit water was being sent daily to this locality from another well a little distance off."*

In the village.

Sunk and communicated by — THUXTON of Hethersett.

Boulder Clay, to gravel, 25 feet.

Bedingham.

Ordnance Map 176, new ser. (Norfolk 98, N.W.). Geologic Map 66, S.E.

Sunk and communicated by D. PALMER.

[Chalky Boulder] Clay	30	60 feet.
[Glacial Drift and Crag?] Sand and brickearth	30	

Besthorpe.

Ordnance Map 161, new ser. (Norfolk 85, S.E.) Geologic Map 66, S.W.

Wells sunk and communicated by — POOLEY.

1. Fox and Hounds Inn.

Loam	3	14 feet.
Black Clay	7	
Gravel	4	

2. Close by the Prince of Wales Inn.

Gravel	4	10 feet.
Red sand, to white sand	6	

3. Corner of Sluts Lane.

[Boulder Clay]	10	17 feet.
White sand. Water rose to surface	7	

4. On Norwich Road by 13th milestone.
   Gravel. Water rose to surface, 12 feet.

And the following, in Boulder Clay.

5. A little north of 4. Boulder Clay, 60 feet.
6. Heron's Farm. Boulder Clay. Small supply of bad water, 87 feet.
7. Prince of Wales' Inn. Loam 2 feet. Boulder Clay 6 feet.
8. A mile east of the church. Boulder Clay 18 feet.

Billingford.

Ordnance Map 175, new ser. (Norfolk 110, N.E.). Geologic Map 50, N.E.

Rectory.

Sunk and communicated by W. LIMMER of Dickleburgh.

Water rose 4 feet.

[Glacial Drift] ...	Gravel and sand	45	70 feet.
	Loam	10	
Chalk		15	

* Report to the Local Government Board, No. 81, p. 2.

Bilney, East.

Ordnance Map 146, new ser. (Norfolk 36, S.E.) Geologic Map 66, N.W.

BILNEY HALL.

Made and communicated by Messrs. ISLER & Co.

Lined with 40 feet of 5 inch tubes a foot down ; with 120 feet of 4 inch tubes, 3 feet down ; and 75 feet of 3 inch tubes 105 feet down ; water-level 8 feet down.

		Thickness feet.	Depth feet.
Dug well	(the rest bored)	—	6
[Glacial Drift]	Ballast (gravel)	6	—
	Clay	32	—
	Loamy sand...	8	—
	Sand	4	—
	Sand and ballast	6	—
	Ballast	11	—
	Flints	2	75
[Upper]	Chalk	105	180

Bilney, West.

Ordnance Maps 146, 160, new ser. (Norfolk 46 N.W.). Geologic Map 65.

1. W. G. E. Wyrley-Birch supplies part of the parish, from wells in Carstone.

Quantity plentiful, quality good.
Local Government Board Return, 1915, p. 293.

2. A few hundred S. of a pit adjoining the garden of Bilney Lodge (West Bilney Hall of the newer Map).

C. B. ROSE. *Phil. Mag.*, 1835, ser. 3, vol. vii., p. 17.

Lower Greensand	Ferruginous sand, with geodes and hollow cylinders of ironstone	7	27½ feet.
	Carstone	8	
	White sand, with occasional brown veins		
	Green clay	7½	
	Carstone, darker than the beds above ...	2	
	Carstone, with six or seven partings of green clay (1 to 2½ inches thick) not in regular courses	3	

3. ? At the brickyard on the northern side of the road, nearly three-quarters of a mile north-westward of the church.

C. B. ROSE. *Phil. Mag.*, 1836, ser. 3, vol. viii., p. 31.

Well in Nar Valley Beds (clayey), with marine shells, 40 feet.

In *Proc. Sci. Soc. Lond.*, 1840, vol. ii., p. 61, he adds, that the lower part of the beds getting sandy it is probable that the Lower Greensand is close beneath.

4. School-house.

C. B. ROSE, *Phil. Mag.*, ser. 3, vol. vii., p. 181.

Passed through the same set of beds as at Pentney (*see* p. 110) the Gault containing fossils.

Bintree.

Ordnance Map 147, new ser. (Norfolk 37, N.). Geologic Map, 68, S.W.

Manor House, southern end of village, 1917.

Made and communicated by Messrs. FAKE (with specimens, noted in these brackets).

Sunk well, with land-spring, 16 feet, the rest bored.

		Thickness feet.	Depth feet.
[Boulder Clay.]	Well in bed like that next below ...	—	16
	Clay (yellowish-brown, sandy, with small bits of shell)	7	—
	Dark clay (yellowish-brown, sandy, with small bits of shell and chalky streaks	8	—
	Light-blue clay with chalk (pale grey Boulder Clay)...	10	41

Bintree—*continued.*

		Thickness feet.	Depth feet.
[Glacial Gravel, etc.]	Shingle (pebbles)	1	—
	Rough sea-sand (with bits of flint) ...	4	—
	Clay (brownish, sandy)...	10	—
	Black clay, sand, and loam (light-grey sandy clay)	1½	—
	Mixed sand and clay (brownish sandy clay)	3½	—
	Stones (pebbles)...	2	—
	Rough sand (with pebbles)	5	68
[Upper Chalk]	Marl (Chalk)	26	—
	Chalk	50	144

The differences between the descriptions given and those from the specimens are probably owing to the former having been made when the material was brought up, and was therefore wet. On drying clays and loams often change their look greatly. From 61 to 68 feet may be the equivalent of the Westleton Beds. An abundant supply of water was got. For analysis, *see* p. 144.

Bixley.

Ordnance Map 161, new ser. (Norfolk 75 N.E.). Geologic Maps, 66 N.E. and S.E.

1. Communicated by G. C. Burrows to S. Woodward (MS. 1825).

		Thickness feet.	Depth feet.
[Chalky Boulder Clay.]	Brick-earth	2	—
	Blue clay with chalk concretions ...	30	32
[Glacial Drift and Crag.]	Gravel and white sand	20	52
[Chalk.]	White Marl	30	—
	Chalk	10	—
	Hard chalk	15	107

2. The Hall.

Communicated by Mr. D. Palmer, well-sinker.

[Chalky Boulder Clay.]	Very chalky clay	20	—	120 feet.
[Glacial Drift.]	Gravel and sand	100	—	
[Crag.]	Well-worn shingle.			

Mr. Lawrence, well-sinker, informed me that there is a well at Bixley Ha. through 100 ft. of clay to black gravel with bad water. C. Reid.

3. North Henstead Rural District (Public Supply).

From A. Shaw, to the Local Government Board.

124 feet above Ordnance Datum.

Well of 4 feet diameter, lined for 75 feet; bell shaped at the bottom, to 10 feet diameter.

Rest-level of water 96 feet down. Level when pumping 106.

[Glacial Drift.]	Layers of sand and loam, about 40	109 feet.	
Chalk	69		

According to the Local Government Board Return, 1915, p. 293.

R. J. Colman supplies part of Trowse-with-Newton, from

1. Well in Chalk at Bixley (?No. 1 or 3). Average daily quantity obtained 3,100 gallons.

2. Spring, intercepted underground, from gravel, Poringland Avenue, Framingham Pigot. Quality good.

Blakeney.

Ordnance Map 131, new ser. Geologic Map 68, N.W.

Blakeney Point (Norfolk sheet 4).

In the Report of the Blakeney Point Committee of Management for 1914 (*Trans. Norf. Nat. Soc.* 1915, vol. x., pt. 1, pp. 67–69), the following particulars of wells sunk in the shingle are given. They are of more than local interest, as illustrating water-supply from that source.

For the purpose of "dealing with the distribution of fresh water in the shingle beaches, its changes of level and relation to the underlying salt-water table," in July four wells were dug in line, at distances of from 20 to 200 feet from high water-mark, shored up, covered, and left to settle until August, when "daily readings of the height of the water in the wells throughout two complete tidal cycles (August 9th—September 10th) and occasional readings during the autumn and winter" were made.

"Broadly, the readings show that the water-level in all the wells begins to rise from 48 to 96 hours after the cycle of tides begins to spring (*i.e.*, after the lowest neaptide) and that they continue to rise for corresponding periods after the date of the highest springtide—the amount of lag being greatest in the well most remote from the sea. The well nearest the sea showed the greatest range of rise and fall (20 inches), that farthest away the least (14 inches); the intermediate wells behave . . . in an intermediate manner. About 48 hours after the highest spring tide the water in all the wells stands at about the same level—sometimes within an inch. In another cycle the difference at the corresponding place was three inches. On the other hand the maximum differences in level occur 48 hours after the lowest neaptide (1 foot or more)."

"These obseravtions indicate that the freshwater table . . . is approximately horizontal about 48 hours after the highest spring tide, whilst 48 hours after the lowest neap, the table slopes down to the shore with a gradient of 1 in 200. In other words the oscillation of the water table is greatest nearest the shore, least at the inland station. The influence of the tidal cycles is felt first at the seaward well, last at the inland. The fall of individual tides has no perceptible effect on the water level in the wells. It is the aggregate of the tides in a waxing or waning cycle that determines the rise and fall . . . The advent of the spring tide cycle may be compared to a horizontal wedge of seawater driven in beneath the freshwater table and raising first the water in the outside well and ultimately that in the well most remote from the sea."

"The effect of rainfall is marked, especially under certain conditions of tide, whilst other factors, such as evaporation, make themselves felt."

Samples of water have been analysed for chlorides, with the following typical results, the figures being grams of Na Cl per litre.

	Sept. 26.	Nov. 21.
Well 1, nearest the sea	·459	·723
„ 2	—	·298
„ 3	—	·14
„ 4, farthest from sea	·092	·094

"The sea-water at the higher spring tides stands 2–3 feet above the water level in the outermost well, high water mark being distant about 20 feet. Under the circumstances it is remarkable how relatively free the well is from percolation."

"When a well is pumped dry it fills in about ten minutes. Thus the supply is practically inexhaustible." But one may ask how long does it take to pump a well dry?

In a later Report the effect of the high tide of September 16th, 1916, is described, and we are told (*Trans. Norfolk Nat. Soc.* 1918, vol. x., pt. iii, pp. 247, 248)—

"The wells which were overwhelmed by the tide made a remarkably speedy recovery, as the following table from data supplied by Dr. Sarah Baker will show. . . 3·19 per cent. salt is the normal contents of sea water at Blakeney Point."

Date, 1916.	Per cent. salt.	
Sept. 14, a.m.	3·19	Low flooded.
„ 16, p.m.	3·23	Water still in Low.
„ 21, a.m.	1·46	Low empty.
„ 22, p.m.	1·19	
Oct. 2	·53	

"On September 15th and 16th heavy rain fell."

The samples were from well 3. In less than three weeks the salt percentage had fallen greatly. "No determination has been made since, but there is every reason to suppose that progress towards the normal has continued. At ordinary times this well contains about ·015 per cent. salt."

Blofield Rural District.

Reporting in 1912, the Medical Officer says that, except for Thorpe St. Andrew, to a small extent supplied from the Norwich mains, the district is dependent on wells. Some of these are 50 feet or more deep, with good water; but "in the low-lying villages the wells necessarily shallow and the water often contains a large amount of organic matter in solution."

See also under *Reedham*.

There are deep borings in Blofield, yielding normal Chalk-waters, but we have no details.

Blo' Norton.

Ordnance Map 175, new ser. (Norfolk 109, N.W. and N.E.). Geologic Map 50, N.W.

1. The Hall.

Communicated by Rev. G. Norris, the owner.

Tube-well into the Chalk at 54 feet. The tube driven in 4½ hours.

Water rose to within 4 feet of the surface. ? 100 gallons a minute.

2. Messrs. Gidney made a well, for the Rev. G. Norris, which may be at the same place as the above (or ? at the Rectory 1891). Their account is as follows:—

Sunk 20 feet, the rest bored.

		Thickness feet.	Depth feet.
Soil		2	2
Glacial Drift	Sand	8	10
	Blue Clay	132	142
[Upper] Chalk with flints		20	162

3. Grange Farm. 1894.

Made and communicated by Messrs. Gidney.

Sunk 10 feet, the rest bored.

		Thickness feet.	Depth feet.
Soil		1	—
Boulder Clay ...	Light-coloured clay	8	—
	Blue clay	20	29
Glacial Sand and Gravel	Sand	16	—
	Gravel	14½	—
	Loamy sand	29	—
	Gravel	½	89
[Upper] Chalk with flints		18	107

Bressingham.

Ordnance Map 175, new ser. (Norfolk 104, S.E., 105, S.W., and 109, N.E.). Geologic Map 50, N.W.

1. The Hall.

Sunk and communicated by W. Limmer of Dickleburgh.

[Boulder] Clay, to Sand, with water, 15 feet.

2. The Common.

Sunk and communicated by George Banham, of Winfarthing.

[Boulder] Clay, to Sand, with water, which rose 10 feet, 30 feet.

3. The Fen.

Sunk and communicated by G. Banham.

Water rose 22 feet.

[Boulder] Clay	20	28 feet.
Sand	8	

Brinton.

Ordnance Map 131, new ser. (Norfolk 17, E.). Geologic Map 68, S.W.

The Hall?

Communicated by F. LAVANCHY.

Water overflowed.

Drift	62	102 feet.
Chalk	40	

Broome.

Ordnance Map 176, new ser. (Norfolk 98, N.E.). Geologic Map 66, S.E.

1. Broome Place. 1888.

Sunk and communicated by MESSRS. ISLER & Co.

Lined with 10 feet of 6-inch tubes, 10 feet down, and 114 feet of 5-inch tubes 7 feet down.

(Water-level 54 feet down. Yield 1,020 gallons an hour.)

		Thickness feet.	Depth feet.
Sunk hole (no record)		—	10
[Valley Drift], Ferruginous gravel and sand ...		30	40
[Boulder Clay, 32 feet.]	Yellow clay	12	—
	Chalky boulder clay	20	72
[Pebbly Series, 29 feet.]	Flint pebbles	9	—
	Flint gravel and sand	20	101
[Norwich Crag, 48 feet.]	Grey gravelly sand, with shells	16	—
	Shell-bed	2	—
	Loamy sand and shells ...	2	—
	Grey sand	5	—
	Sand and shells...	6	—
	Gravel and shells	4	—
	Coarse loamy sand, with shells	6	—
	Fine sand and shells	7	—
	Flints	1	150
Chalk and flints		50	200

The classification by C. REID, who gives a list of the shells found, especially between 112 and 116 feet, in "The Pliocene Deposits of Britain," 1890, pp. 110, 111.

2. Coopers Farm.

From information obtained by C. REID.

[Chalky Boulder] Clay	12	58 feet.
Gravel and sand (none fit for mortar)	46	

Brumstead.

Ordnance Map 148, new ser. (Norfolk 30, S.W., 41, N.W.) Geologic Map 68, E.

Half a mile west of the church and close to the Alluvium.

Recorded by C. REID.

Soil and loam	2½	7½ feet.
Fine whitish sand, with 2 feet of water	5	

Brundall.

Ordnance Map 162, new ser. (Norfolk 64, S.W.). Geologic Map 66, N.E.

H. P. Read's, 1900? (? Market garden).

Made and communicated by W. E. FAKE.

Brick well 20 feet. Boring (tubed) 160 feet.

Water-level 60 feet down, or about river-level.

Mr. READ says (Sept., 1900) that a three-throw 3¾-inch pump has been working nearly every day, about 25 strokes a minute. It will keep this supply night and day, as long as needed.

Buckenham, New.

Ordnance Map 175, new ser. (Norfolk 96, N.W. and S.W.). Geologic Map 66, S.W.

Two wells, sunk and communicated by J. BANHAM.

1. In the Town.
   Sand, 16 feet.

2. Near the Church.
   [Boulder] Clay. Water rose 20 feet, 30 feet.

Buckenham, Old.

Ordnance Map 175, new ser. (Norfolk 95, N.E.). Geologic Map 66, S.W.

Sunk and communicated, 1, 2 by J. BANHAM, 3 by — LINCOLN.

1. The Hall.
   Clay and marl, 20 feet.

2. Mr. Salter's.
   Gravel and sand, 10 feet.

3. On the Fen.
   Marl, fenny bottom, 31 feet.

4. The Hall (later well).

Made and communicated by MESSRS. ISLER and Co.

Lined with 20 feet of 8½-inch tubes and 60 feet of 6 inch.

Water-level 24 feet down. Supply 1,200 gallons an hour.

		Thickness feet.	Depth feet.
[Glacial Drift]	Loam	2	—
	Loamy sand	2	—
	Clay and chalk (mixed) ...	7	—
	Ballast [gravel]	10	—
	Clay and ballast	1	22
[Upper] ...	Chalk and flints	128	150

Bunwell.

Ordnance Map 175, new ser. (Norfolk 86, S.W., 96, N.W.). Geologic Map 66, S.W.

Wells sunk and communicated by — POOLEY.

Two wells in Boulder Clay.

1. Bunwell Street, by the chapel. Boulder clay, 23 feet.
2. In Bunwell Wood. Boulder Clay, 25 feet.

Two wells through Boulder Clay.

3. Close by No. 1. Boulder Clay, to sand and water, 60 feet.
4. In Brickkiln Lane. Boulder clay, to sand and water, 20 feet.

Burlingham, South.

Ordnance Map 162, new ser. (Norfolk 65, S.W.). Geologic Map 66, N.E.
Old Hall. From H. B. WOODWARD'S Notes.

[Glacial Drift] { Loam, 12 feet.
Sand, 70 or 80 feet to water.

Burnham Westgate.

Ordnance Map 130, new ser. (Norfolk 7, N.E.). Geologic Map, 69.

Information obtained by A. C. G. CAMERON and G. BARROW.

1. House facing Norton Road.

Sand and gravel	16	}	40 feet.
Hard chalk	24	}	

2. Cobbler's Hill Farm. Chalk, 134 feet. G. BARROW notes a well at Cobbler's Hill Plantation as 130 feet to water, the level of which varies, though the well is never dry.

3. Sussex Farm, in the valley about 1¾ miles west of the town. Chalk, 100 feet, the upper part marly, and with a thin covering of gravel.

4. Friar Thorn Farm, on the main road to Docking about 1½ mile from the church. Depth of water in April, 1883, 40 feet.

Boulder Clay	30	}	180 feet.
Chalk	150	}	

5. Cradle Hall, south-west of the last. Well said to be 200 feet deep, but probably not so much, as it went dry once in a dry summer. Depth of water in April, 1883, 30 feet.

Burston.

Ordnance Map 175, new ser. (Norfolk 105, S.W. and S.E.). Geologic Map 50, N.W.

1, 2, sunk and communicated by G. BANHAM.

1. The New Schools.

[Boulder] Clay	45	}	48 feet.
Sand. Water rose 7 feet	3	}	

2. West of Church.

[Boulder] Clay, to Sand, 26 feet.

Water rose 23 feet and sometimes overflows.

3, 4, sunk and communicated by J. BANHAM.

3. Mr. Dixon's Farm.

Sunk 40 feet, bored 25.

[Boulder] Clay, to Sand. Water rose 20 feet, 65 feet.

4. Crown Inn.

Sunk 40 feet, bored 20.

[Boulder] Clay, to Sand. Water rose 20 feet, 60 feet.

Bylaugh.

Ordnance Map 147, new ser. (Norfolk 49, N.E.). Geologic Map 66, N.W.

Bylaugh Park. Brickyard about three quarters of a mile N.E. by N. of the church.

Shaft 80 feet; the rest bored. Water about 77 feet down.

[Drift.] To Chalk (no record of the beds passed through)	80	}	120 feet.
Chalk	40	}	

The information respecting this well was communicated on the spot, in August, 1883, by the manager of the brickyard, who stated that his family had worked it for between 60 and 70 years. The well was sunk about 50 or 60 years ago [1823–1833], and the boring was made in hopes of getting a better supply of water. There were six hollow trunks of trees inserted, with suckers 60 feet down; but the well on most occasions was soon pumped dry, and it had not been used for about 30 years. The brickyard is now supplied with water conveyed in pipes from the river, being forced up by means of the water-wheel at Elsing Mill. *See* account of well at Elsing, p. 84.

Cantley.

Ordnance Map 162, new ser. (Norfolk 77, S.W.). Geologic Map 66, S.E.

Anglo-Netherland Sugar Factory, between the river and the railway, about half a mile S.E. of the church. 1912.

Made and communicated by MESSRS. FAKE. A 4-inch boring.

Abundance of pure water.

		Thickness feet.	Depth feet.
[Glacial Drift.]	Soil and clay	12½	—
	Peat	2½	—
	Sand, discoloured by peat	3	—
	Blue sand and stones*	4	22
	Dark sand and stones*	1½	—
	Dark clay	4	—
	Hard stone	1	—
	Dark clay	33½	—
	Blue clay	38	—
	Cocoa-coloured clay	16	—
	Blue clay, with occasional streaks of green	62	178
[Upper Chalk.]	Chalk stone, very hard. Here water rose 8 feet above ground. Tubes driven down to stop it	10	—
	Chalk. Borehole unlined	7	195

* Colour when drawn from the borehole.

PROF. P. G. H. BOSWELL classifies the beds between 22 and 178 feet as London Clay.

For analyses of the water, *see* p. 145.

Carleton, East.

Ordnance Map 161, new ser. (Norfolk 75, S.W.). Geologic Map 66, S.E.

1. Lord Justice Lindley's.

Made and communicated by MESSRS. LEGRAND and SUTCLIFF.

Water-level 14½ feet down, May, 1884.

		Thickness feet.	Depth feet.
Dug well (the rest bored)...		—	3
[Drift.]	Loamy clay	12	—.
	Sand and gravel	10	25
Soft chalk and flints		55	80

2. The Hall.

Communicated by — SWAN.

[Glacial Drift.]	Gravel	30 feet.
	Clay	
[Crag.]	Gravel, to chalk	

Carleton Forehoe.

Ordnance Map 161, new ser. (Norfolk 74, N.W.). Geologic Map 66, N.W.

The School.

Sunk and communicated by — THUXTON, of Hethersett.

Boulder Clay, 25 feet.

Carleton Rode.

Ordnance Map 175, new ser. (Norfolk 96, N.W.). Geologic Map 66, S.W.

Three wells, sunk and communicated by J. BANHAM.

1. Mr. Austin's cottages by turnpike-road.

Sunk 40 feet, bored 20 feet.

(Boulder) Clay, to sand, water rose 20 feet, 50 feet.

2. Mr. Bett's, by side of turnpike-road.

Sunk 40 feet, bored 20 feet.

(Boulder) Clay, to sand, water rose 30 feet, 60 feet.

3. In Hargate, three-quarters of a mile south-east of the church.

(Boulder) Clay, moory bottom, 30 feet.

MR. BANHAM sunk 20 more wells in Carleton Rode from 20 to 30 feet in (Boulder) Clay; water-supply from "land springs."

Castle Acre.

Ordnance Map 146, new ser. (Norfolk 47, N.W. and S.W.). Geologic Map 65.

New Rectory.

Information from the builder, to C. E. HAWKINS.

[Glacial Drift]	Clayey stuff	14	34 feet, to Chalk.
	Shingly	20	

Castle Rising.

Ordnance Map 145, new ser. (Norfolk 22, S.E., and 33 N.E.) Geologic Map 69

1. Rising Lodge Farm, on the high road, a mile south of Castle Rising.

Sunk and communicated by J. FAKE, of Norwich, 1881.

Gravel and Sand [Lower Greensand], 105 feet.

2. Another well sunk about 100 yards east of the above is said to be about 113 feet deep.

3. Cottage at foot of hill, three-quarters of a mile east of South Wootton.

Sunk and communicated by J. FAKE, of Norwich.

Water rose 30 feet.

Brick-earth	about 7	39 feet.
Red clay	,, 2 or 3	
Blue clay, to sand [Lower Greensand]	,, 29	

4, 5. Communicated by F. VALENTINE, in 1897.

4. Catton's Garden. Northern side of the road to Lynn, westward of the Hall.

Soil	4	44 feet.
Boulder Clay	40	

Not carried through to the sand, enough water being got from a thin layer of sand in the clay.

5. At the back of the New Black Horse Inn, south of the church. 1896?

Well 55 feet, the rest bored.

Made soil and marl	8	70 feet.
Boulder clay, to clean sand, from which an abundance of water rose into the well	62	

As MR. VALENTINE remarks, they show a deep mass of Boulder Clay where none has been marked on the map.

Cawston.

Ordnance Map 147, new ser. (Norfolk 38, N.E.). Geologic Map 68, S.W.

Cawston Manor, 1898 ?

Made and communicated by Messrs. Easton, Anderson & Co.

87½ feet above Ordnance Datum.

Well 29 feet 4 inches, the rest bored.

Standing water-level, 19½ feet down.

Yield at the rate of 20 gallons a minute, from the bottom of the bore.

		Thickness. Feet.	Depth. Feet.
Peat		1	1
[Glacial Drift]	Yellow sand	17	—
	Ballast [gravel] and water	5	—
	Brick-earth	2	—
	Gault [Boulder clay. C. Reid]	38	—
	Sharp greensand and water	5	68
[Crag, C. Reid]	Fine greensand ... nearly	2	70

Cley.

Ordnance Map 131 (Norfolk 9, N.E.). Geologic Map 68, N.W.

The Rectory, 1905.

Made and communicated by W. G. Fake (of Norwich).

Shaft 90 feet, the rest bored.

Good supply

		Thickness. Feet.	Depth. Feet.
[Drift]	Grey clay	20	—
	Sand and gravel	50	—
	Grey clay	5	—
	Loam sand	10	—
	Blowing sand	5	—
	Fine blowing sand	15	—
	Gravel	7	—
	Shale [? laminated clay]	8	120
[Chalk]	Marl and flints	10	—
	Chalk	35	165

(Total given as 175).

Congham.

Ordnance Map 146, new ser. (Norfolk 34, N.W.). Geologic Map 69.

Congham House, three-quarters of a mile E.S.E. of the church. 1914 ?

88 feet above Ordnance Datum.

Made by A. Fake (of Norwich). Communicated by E. T. Beardmore (with specimens, noted by G. W. Lamplugh).

Sandy gravel, about 15 feet.

Grey chalky boulder clay (specimen).

Dark chalky boulder clay (specimen from 180 feet). Total depth unknown.

Dark calcareous clay (specimen from the bottom, 243 feet : probably Kimeridge Clay).

The boring seems to be in a deep Drift-filled valley, in which the Gault and Lower Greensand are cut out. Boring abandoned. No water.

Mr. Child (a diviner) is said to have marked a spot within 20 feet of this boring, where a good supply would be got 50 feet down by a well of 5 feet diameter.

Crimplesham.

Ordnance Map 159, new ser. (Norfolk 69, N.E.). Geologic Map 65.

1. From C. REID'S Notes.

Boulder clay	28	33 feet.
Gault [Chalk Marl]...	5	

2. The Hall. 1905.

Communicated by B. W. BRYAN and (specimens) by MESSRS. FAKE, who made the boring.

120 feet above Ordnance Datum.

Shaft 27½ feet, the rest bored.

MESSRS. FAKE report that the Lower Greensand was dry, no water being met with in making the borehole. A fair amount of water at 27 feet down. Yield tested later and reached only 28 gallons an hour.

		Thickness. Feet.	Depth Feet.
[Glacial Drift.]	Grey clay...	16	—
	Loam	1	—
	Stiff white sand	5½	—
	Very fine soft white sand	2½	—
	Blowing sand (27½ to 30½ fine grey sand)	5½	30½
	Blue clay (dark grey clay with small bits of chalk)	16½	47
[Lower Greensand, 66½ feet.]	Oolites (calcareous sandstone, greenish, with casts and impressions of shells ? phosphatic nodules)	4	—
	Dark blue sand	2½	—
	Green sand	10	—
	Nodules (pyrites and sandstone and pyrites)	¼	—
	Blue sand (fine greyish sand)	17¾	—
	Green clay	1½	—
	Hard sandstone (with hard black nodules, small bits of pyrites, and some clayey matter, carried down?)	3	—
	Blue sand	2½	—
	Clay and sand	2	—
	Hard porous stone, light in weight ...	2½	—
	Blue sand	½	—
	Green sand and loam. After water settling from it, became hard (hard light-green sand, with some clay and bits of stone, at bottom)	2	—
	Hard stone	2¾	—
	Green sand	3	—
	Hard blue sand (fine pale grey sand) ...	2¼	—
	Hard stone (sandstone, one specimen calcareous)	4½	—
	Blue sand	2½	—
	Hard stone	1	111½
	Green sand and slate-coloured clay ...	2	—
[Kimeridge Clay.]	Thin layers of stone and blue sand ...	2	—
	Blue sand, with hard stone at 116½–117	4	—
	Black clay	1	120½
	Green and slate-coloured clay	2½	—
	Hard stone	2	—
	Blue sand	3	—
	Thin stone and black clay	4	—
	Blue sand	2½	—
	Fine blue sand	5	—
	Black clay	4	—
	Dark blue clay	?	242½

Crimplesham—*continued.*

The specimens and the descriptions sent with them differ somewhat from the above, below 112 feet, as follows :—

Black clay, blacker when fresh from the bore, but lighter since exposed to the air (very dark grey, with some bits of shell), 112 to 116 feet.

Dark blue clay (dark grey, with bits of shell), 116 to 241 feet.

Light-blue clay (grey clay, nearly as dark as the above, with bits of shell), 241 to 242½ feet.

From these specimens it seems clear that the Kimeridge Clay is reached at 112 feet.

The blue clay from 30½ to 47 feet, or part of it, may be Gault.

According to the Report of the Medical Officer of the Downham Rural District, in 1913, "At Crimplesham the water supply is unsatisfactory. In the village street there are several wells but in only two of these is the water considered fit to drink."

See also *West Dereham*, p. 77.

Cromer.

Ordnance Map, 131, new ser. (Norfolk 11, E.). Geologic Map 68, E.

1. Gas Company.

Communicated by F. BENNETT, of Ipswich, who continued the boring in 1902, driving a 6-inch tube down to 137 feet.

Yield, after Bennett's boring was done, between 1,600 and 1,700 gallons an hour. Water first class, free from salt ; stood 99 feet down, varying from 18 to 20 inches, according to the tide.

	Thickness. Ft. Ins.	Depth. Ft. Ins.
Well, previously sunk	—	114 0
Hardpan	1 0	115 0
Rough ballast [gravel]	5 0	120 0
Running sand	5 2	125 2
Flints	2 0	127 2
[Upper] Chalk, with flints at 143, 144, 146, 147, 149, 150, 153, 155½, 157, 159, 162, 165, 171, 174 and 179 feet...	72 10	200 0

2. Waterworks. About 900 yards south of the church. 1880 (?). 117 feet above high water of spring-tides. Taken over by the local authority in 1902. Well 81 feet, then bored.

Description by C. REID, Cromer Memoir and *Proc. Norwich Geol. Soc.*, pt. v., 1881, pp. 129–131 :—

"In sinking this well much difficulty was found, owing to the number of small springs in the Boulder-clay, which ought to be carefully shut out. For 61 feet the original plan was adhered to, and the well lined with brickwork. Then the beds became so full of water, that it was found necessary to use cylinders ; but at 81 feet the cylinders entered stiff Boulder-clay on one side, while the other was in quicksand, which flowed in as fast as it was cleared out. At last the cylinders were forced into the clay, and it was decided to abandon the plan of sinking the well further and commence boring."

A 13-inch bore was carried to 141 feet, when the shell used to extract material entered a bed of flints and became fixed. It had to be broken and a smaller bore was carried down and lined with a 9-inch tube to 173 feet. Then boring was continued, with a diameter of 8 inches, the 9-inch tube being afterwards driven down a further 24 feet in order to shut out the water from the clays and sands.

After the well was completed, on pumping, the bore rapidly filled with sand and clay, which rose till passing the spring in the Chalk and reaching the base of the lining tube.

After delays a good supply was got from the Chalk, continuous pumping of 10 hours daily for three weeks not reducing the level of the water.

The details of the beds are in the upper part from his own measurements, and the rest from a section of E. R. PRIEST'S. "The first 110 feet belong to beds so much contorted, that as far as the well was sunk, the two sides gave quite different readings."

Cromer—*continued.*

In one case REID gives the figures for both sides down to the depth of 42 feet, and in the other to that of 82½ and 81½. In the following account I have taken the mean: both descriptions have been used.

There must be some slight error in the figures, the total depth being given as 400 feet.

		Thickness. Feet.	Depth. Feet.
Soil		1	—
Contorted Drift, 111½ feet.	Brown brick-earth, with a few scattered angular flints and pebbles of flint and chalk; occasional seams of lead-coloured clay. *Cyprina Islandica*, *Tellina Balthica* and *Cardium edule*	7	—
	Buff fine sand, rather loamy... ...	3¼	—
	Brick-earth, as above	1¼	—
	Buff loamy sand with a few stones...	3¼	—
	Light-lead-coloured boulder clay ...	6¼	—
	Sand, with occasional subangular flints. Water at the base (bad) ...	5¾	27¾
	Blue clayey loam, with very few stones or fossils. Thin seams of sand, with a little water at the base ...	14¼	42
	Blue-black clayey loam, with a few stones and shell-fragments ...	18	—
	Soft mud and clay. Water at 61 and 69 feet	19	79
	Wet blue clay and running sand ...	3	—
	Stiff clay	4½	—
	Very firm clay	6	—
	„ „ of a lighter colour ...	6	—
	„ „ of a darker colour ...	5	—
	„ „ hard, with flints ...	1	—
	Soft, wet sandy clay	1½	—
	Hard blue earth (water-level at 111 feet)	6½	112½
Pliocene Beds, 29½ feet.	Soft blue earth	4	—
	Wet sandy earth, with flints... ...	7	—
	Running sand, with flints	5	—
	Carbonaceous clay and fine gravel, with a little lignite, described as like concrete	13	—
	Flints (the stone-bed)	½	142
Upper Chalk, 258½ feet.	Chalk, with 9 inches of flints at the base	3¾	—
	Marl, chalk and blue clay, mixed (the clay probably fallen from above when the bore was enlarged) ...	26	—
	Chalk. 3½ feet of flints below 182¾ feet. Large flint (1½ feet) below 210¼. Flints below 232, 252, 256½, 276 (1½ feet), 283, 298, 302½, 345½, 383 (1½ feet) and 386½ feet ...	228¾	400½

According to an account in the EASTERN DAILY PRESS, May 11th, 1892, a new well was finished in that year to a depth of 183 feet, reaching the Chalk at 138 feet. It was lined to the depth of 151 feet, with brickwork and iron cylinders, and a borehole of 20 inches diameter was taken to a further depth of 40 feet. Two headings were driven, one joining up with the older well. The permanent water-level is 110 feet down. The well and headings have a storage-capacity of about 25,000 gallons. The total yield it is estimated will be at least 200,000 gallons a day.

A letter of June, 1900, from P. E. HANSELL (Secretary of the Company), says that a 12-inch borehole has been carried down to about 260 feet; that the total length of the headings is 796 feet, that most of the water comes from the south-

Cromer—*continued.*

west; that the older well and borehole has been abandoned; and that the water-level in the present well, before pumping, is 122 feet below the engine-room-floor, the level having been permanently reduced about 11 feet since 1877.

The following gaugings were made in 1899 :—

Days of maximum pumping.	Gallons.	Depth of water in well, in feet. at starting.	at stopping.
24 hours. August 3 ...	251,713	25	20
27 „ „ 10 ...	271,129	46	20
26¾ „ „ 23 ...	285,492	45	18
Minimum day's pumping.			
January 21	48,318	50	25

According to the Local Government Board Return of 1915, p. 142, the Cromer works also supply part of Felbrigg, Northrepps, Overstrand, Roughton, Runton, and Sidestrand. Many other parishes are within the limits of supply. The average daily quantity, from the Cromer and Metton Works, was 227,000 gallons. Much more could be got.

The Waterworks Directory of 1911 gives the population supplied as about 6,000.

See also under **Metton.**

Denton.

Ordnance Map 176, new ser. (Norfolk 107, N.W.). Geologic Map 66, S.E.

Mr. Doole's.

Communicated by Mr. LAWRENCE.

Clay, about	71	} 89 feet.
Sand, to water, about	18	

Deopham.

Ordnance Map 161, new ser. (Norfolk 73, S.E, 85, N.E.). Geologic Map 66, S.W.

Three wells, sunk and communicated by — LINCOLN, of Attleborough.

1. Low Common.
   Black sand. Water rose to surface, 8 feet.

2. Near the Church.

Glacial Drift	Gravel	4	} 14 feet.
	Brick-earth	10	

3. One mile south of the Church.
   (Boulder) Clay, to Chalk, 90 feet.

Depwade Rural District.

The Medical Officer reports, in 1912, "No public water service exists in the district, in several of the larger houses, factories, and maltings good water is obtained by deep boring." Most of the drinking water is got from shallow wells, with a danger of pollution.

Dereham, East.

Ordnance Maps 160, 161, new ser. (Norfolk 49, S.W. and 61, N.W.). Geologic Map 66, N.W.

1. Near the National School, about three eighths of a mile N.E. of St. Nicholas' Church.

Level of water, 30 feet down.

Post-Glacial.	Brown loam	14	} 35 feet.
Glacial Drift	Boulder Clay	2 to 3	
	Gravel and sand	18	

Dereham, East—*continued.*

2. Waterworks, a little more than half a mile N.E. by N. of St. Nicholas' Church. 1880.

Account by J. H. Blake.

216 feet above Ordnance Datum.

Shaft and cylinders 94 feet, the rest bored (10 inches diameter to the depth of about 100 feet, then 8 inches).

Water rose to 62 feet below the surface; supply abundant.

A most careful record of the formations penetrated was kept by the contractor, J. Villiers of Beverley, by whom it was communicated. I also at various times inspected the operations, and carefully examined specimens of the formations passed through.

		Thickness. feet.	Depth. feet.
[Plateau gravel, &c., 19 feet.]	Soil	2	—
	Brown sand and gravel	5½	—
	Brown loam with flints	4	—
	Brown strong clay with flints	6½	—
	Brown sand and gravel	1	19
[Upper.]	Boulder Clay, grey marly clay, with chalk, flints, &c.	6	25
[Middle Glacial, 69 feet.]	Brown sand and gravel	3	—
	Coarse flints and gravel	10	—
	Light-brown sand and gravel, with chalk grains and occasional large flints	18	—
	Red sand and gravel	14	—
	Light-red sand	20	—
	Red sand and small flints	4	94
[Lower.]	Boulder Clay, consisting of dark bluish-grey marly clay, with pieces of chalk and fragments of marine shells	26	120
[Chalk, 65 feet.]	Soft marly chalk	10	—
	Soft chalk, with five beds of rotten* flint, the middle one 6 inches thick, the rest 4 inches	27	—
	Rotten* chalk	28	185

* So described by the contractor.

The trial-boring, begun on November 4th, 1879, was completed on January 24th, 1880. The progress of the boring, up to January 10th, averaged 3 feet a day until a depth of 180 feet was reached. A difficulty then ensued in keeping the bore-hole open, the chalk being very soft and described as like mud. When a depth of 185 feet had been reached, a test of 72 hours continuous pumping was made direct from the bore-hole, and water was got at the rate of from 60 to 70 gallons a minute, or about 98,000 gallons a day of 24 hours. This result being deemed satisfactory, the boring was not continued.

Water was first met with at a depth of 60 feet and continued to a depth of 94 feet until the Lower Boulder Clay was reached. The bore-hole was tubed as the work proceeded, but, of the 185 feet bored, only 167 were tubed, and the water stood at 62 feet down. Thus, there was apparently only two feet difference of level between the water that was first met with in the red sand and gravel and that which was supposed to be independent of it, and to have risen afterwards in the tube direct from the Chalk. This fact, I considered, was somewhat ominous, for if the sources of the supply were perfectly distinct, and there was no connexion between the water in the Chalk and that in the Glacial sand above, it was, to say the least, a curious coincidence that the level of the water in both cases should have been nearly the same. With reference to this opinion F. Sutton (County Analyst) remarked, "that he was afraid there must be an admixture of the upper and lower waters to which reference had been made, because he never before saw a sample of 'chalk-water' which contained so little solid matter as that obtained from this boring. There must be an admixture of the 'sand-water' with that of the 'chalk-water';

Dereham, East—*continued.*

and if the blue marl [Lower Boulder Clay] was fissured, that would most likely be the case. The hardness given in his analysis was 16° (Clarke's scale). That was most exceptional for 'chalk-water'; and it was evident to him that some softer water must have become mixed with it. But that had nothing to do with its sanitary qualities, for the water seemed to be almost perfect, with the exception of the free ammonia, which was sure to be met with in newly-opened wells."

"This water is practically free from organic matter of any kind, and in my opinion does not contain a trace of sewage impurity. The free ammonia is rather large, but this is invariably the case with 'chalk wells' when first drawn upon, and will lessen as the well is used. In my opinion the water will turn out to be one of the purest supplies in Norfolk, and not excessively hard." (*Proc. Norwich Geol. Soc.*, pt. v., p. 128.)

The analysis of the water is given on p. 149.

"The flow of water from the Chalk is governed by a sluice-valve at the well-bottom, by which (from above) the water can be shut off, and the well pumped dry for any purposes that might be required. . . . From the well the water is pumped into an elevated tank holding 40,000 gallons, and from thence, through an 8-inch sluice-valve, into the 8-inch main service, etc." (W. H. NANKIVELL, Surveyor to Local Board, in the Report of the Medical Officer of Health for 1881.)

According to the Local Government Board Return of 1915, p. 49, the well is 362 feet deep. The daily average supply 50,000 gallons. Much more could be got. The water is excellent. Hardness, total 16°, after softening 8°, permanent 4°.

Population supplied 5,545. Water Works Directory 1911, p. 127.

Dereham, West.

Ordnance Map 159, new ser. (Norfolk 69, S.E.). Geologic Map 65.

1. Cottages near the church.

From A. J. JUKES-BROWNE'S Notes.

Shaft 30 feet and bore 30 feet, through clay to sand [Lower Greensand] and water. The 60 feet must give nearly the full thickness of the Gault.

2. Coprolite Works, 1883. [There is a doubt as to which works are referred to. Those S.W. of the church are in West Dereham, but those nearly a mile westward of the church are more likely in Crimplesham.]

C. REID, *Geol. Mag.* 1886, dec. iii, vol. iii, p. 56.

		feet.
Boulder Clay, very chalky		7
Gault, classed at first as Chalk Marl ...	Blue marl, drying bluish-white	4
	Phosphatic nodules in greenish loamy or sandy matrix, with fossils	¾
Lower Greensand ...	Hard loamy nodular greensand ...	2
	Running sand	2

Dersingham.

Ordnance Map 145, new ser. (Norfolk 23, N.W.). Geologic Map 69.

? For Norfolk County Council, 1912.

A 4-inch boring, made and communicated by MESSRS. FAKE.

No water got. Boring abandoned.

		THICKNESS. feet.	DEPTH. feet.
Soil (mould)		5	5
[Lower Greensand]	Carstone	1½	—
	Blue sand	58	—
	Fine white sand	1½	—
	Blue sand	20	86

Dickleburgh.

Ordnance Map 175, new ser. (Norfolk 105, S.E. and 106, S.W.). Geologic Map 50, N.E.

1. Rectory.

Sunk and communicated by W. Limmer.

Sand (water rose 4 feet), 20 feet.

2. Mr. Smith's. N. of house, at the mill.

Communicated by Mr. Smith.

Shaft, 35 feet ; the rest bored.

A strong spring of water (ferruginous), rose 55 feet.

Sand, 70 feet.

There is some doubt as to these two sections, the surface of the district being Boulder Clay.—(W.W.)

3. Mr. Smith's (miller). E. of house.

Communicated by Mr. Smith.

[Glacial Drift] { [Boulder] Clay ... ... 20 / Sand ... ... 6 } 26 feet.

4. 200 yards E. of Mr. Smith's.

Communicated by Mr. Smith.

[Boulder] Clay, to sand and water, 135 feet.

5. Mr. Simpson's, in the village.

Sunk and communicated by W. Limmer.

Sunk 50 feet, and then bored 50 feet in [Boulder] Clay.

6. Langmere Green, south-eastward of the village (entered under Rushall in the Memoir on 50, N.E.).

Two wells, sunk and communicated by W. Limmer.

[Boulder] Clay, to sand, 50 and 60 feet.

Water rose 9 feet.

Diss.

Ordnance Map 175, new ser. (Norfolk 110, N.W., and 105, S.W. and N.W.). Geologic Map 50, N.W.

1. Brewery.

John Taylor, *Proc. Geol. Soc.*, Vol. II., p. 93 ; and *Phil. Mag.*, Vol. V., p. 295 ; and *Trans. Geol. Soc.*, 1837, ser. 2, Vol. V., p. 137.

Sunk by Thomas Lombe Taylor.

	Thickness. Feet.	Depth. Feet.
7. Clay	50	—
6. Sand	50	100
5. Chalk, without flints, soft and of a marly nature	100	—
4. Chalk, with flints in layers of single stones, distant about a yard from each other ...	330	—
3. Grey chalk, with an occasional layer of white chalk, and free from flints	60	—
2. Light bright blue chalk, approaching to clay, with white chalk stones	20	610
1. Sand	5	615

"On penetrating the light blue chalk, the tools sunk rapidly for about 5 feet, and the water rose to within 47 feet of the surface, at which height it is stated to have continued."

S. V. Wood has referred bed 7 to the Upper Drift, bed 6 to the Middle Drift, and bed 5 to the Lower Drift. *Remarks in Explanation of the Map of the Upper Tertiaries, &c.* (privately printed) 1865. C. B. Rose was disposed to think that bed 2 represented the Gault, and bed 1 the Lower Greensand. *Proc. Geol. Assoc.*, vol. i., p. 229. 1862.

Diss—*continued.*

Another account.

A boring for water in March, 1834.

Communicated to SAMUEL WOODWARD, of Norwich, by T. L. TAYLOR.

	Thickness. Feet.	Depth. Feet.
Blue clay with shells	50	—
Sand and gravel	50	100
Chalk nearly white, without flints	80	—
White chalk with layers of flints	350	—
Grey chalk with layers of white chalk	60	590
Blue clay with chalk stones*	25	615

* "From the specimen this appeared to be Chalk Marl." S. WOODWARD, MS. (H.B.W.)

I am inclined to class only the top 100 feet as Glacial Drift, and the rest as Chalk.

A. J. JUKES-BROWNE says that the 80 or 100 feet of chalk without flints may belong to the zone of *Marsupites*, as suggested by DR. C. BARROIS; that the chalk with flints (330 or 350 feet) may include the zones of *Micraster coranguinum*, *M. cortestudinarium*, *Holaster planus*, *Terebratulina*; that the grey chalk (60 feet) probably represents the zone of *Rhynchonella Cuvieri*; and that the specimen of the "blue" bed (20 or 25 feet) may have come from the Belemnite Marl, at the top of the Lower Chalk. "The Cretaceous Rocks of Britain," vol. iii, 1904, p. 245.

According to MAJOR TULLOCH the water-level was 47 feet down, and 14 days' test-pumping at the rate of about 2,520 gallons an hour failed to lower it more than about a foot. (1908.)

A different and less precise account is given in W. LEE'S Report to the General Board of Health, 1850, p. 6, and the water said to be strongly impregnated with iron.

This brewery has been taken over by LACON & CO. and a few houses (? 14) close by are supplied from it.

2. Brush and Mat Factory. Messrs. Aldrich. 1900.

Bored and communicated by MESSRS. F. SMITH & SON.

A 2-inch boring put down first and then an 8-inch bore.

Water-level 58 feet down. Pump 3,000 to 4,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Old well (the rest bored)		—	60
[Glacial Drift]	Fine sand	10	—
	Rough sand...	9	—
	Blue clay	2	—
	Gravel	16	97
Chalk		263	360

Another account makes the old well only just over 54 feet deep and the total depth 351½ feet; water-level 55 feet down.

After pumping 2,460 gallons in 1¼ hours the water-level was lowered 8½ feet, and further pumping failed to lower it more. 40,000 gallons a day are pumped.

The sinkers have bored several wells in the town and find that the Chalk-level varies very little. Water always good.

3. Waterworks. At the extreme north-western corner of the area. 1912?

Two borings, made and communicated by Messrs. DUKE & OCKENDEN and from the Local Government Board.

138 feet above Ordnance Datum.

Lining tube, of 10 inches diameter to 160 feet.

Water-level 55 feet down.

Yield, tested by continuous pumping for 14 days, 144,000 to 150,000 gallons a day. Level of water before pumping, 83 feet above Ordnance Datum, after pumping 18.

Diss—*continued.*

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	Boulder clay	54	—
	Sand and gravel	5	—
	Sand*	11	—
	Loose sand*	4	—
	Blue clay	4	—
	Gravel	15	93
Chalk	Soft chalk, no flints	155	—
	Soft chalk, few flints	53	—
	Soft chalk	29	—
	Plastic chalk	8	—
	Soft chalk	6	—
	Soft chalk, few flints	8	—
	Soft chalk	48	400

* In one account given as loose sand 14, sand 1.

The pumping test was continuous for 336 hours, except for a stoppage of seven minutes, when in five minutes the water rose from 124 feet to 62 feet. In the next two minutes it rose over 4 feet more, or to within 3 feet of rest-level, and pumping was resumed. The pumping had no measurable effect upon the level of the water in the public borehole a short distance east (? 420 feet) in Shelfhanger Road. The pumping of water hourly from the borehole was from 50 to 70 per cent. in excess of the proposed rate of 4,000 gallons an hour.

According to the Local Government Board Return of 1915, the daily average supply was 12,322 gallons. The water is filtered and softened, and has a hardness of 46·4° before softening.

A slightly different section has been given by W. H. Booth, in *The Power User*, July, 1913. Perhaps this may refer to Well No. 2, which was made by Perkins, Mackintosh & Co. The two wells are "66 ft. apart west and east, No. 1 being 66 ft. from the west boundary, and both wells 66 ft. from the north boundary of the site. Each borehole is a trifle over 400 ft. in depth." There is a well of 12 feet at top. His section is as follows:—

		Thickness. Feet	Depth. Feet.
[Glacial Drift]	Chalky boulder clay	53	—
	Gravel and sand	6	—
	Sand	9	—
	Loose sand	6	—
	Clay	4	—
	Gravel	15	93
Chalk	Soft chalk	69	—
	Very soft chalk	30	—
	Soft chalk and few large flints	38	—
	Soft chalk, very little flint	41	—
	Soft chalk, more flints	14	—
	Soft chalk, less flint	16	—
	Soft chalk	29	—
	Soft plastic chalk	14.	—
	Bands of soft and plastic chalk	49	—
	Soft chalk	7	400

The following table presumably comes from a Report by the Medical Officer, and shows the progress of the supply :—

Monthly pumping record, in gallons.

	1913.	1914.
January	21,000 ...	466,000
February	219,000 ...	423,000
March	271,000 ...	467,000
April	365,000 ...	687,000
May	492,000 ...	785,000
June	502,000 ...	801,000
July	568,000 ...	751,500
August	544,000 ...	787,000
September	427,000 ...	999,000
October	501,000 ...	860,875
November	472,000 ...	760,500
December	453,000 ...	777,875
Monthly average	418,000 ...	713,812

Diss—*continued.*

The average daily consumption in 1913 was 13,726 gallons and in 1914 23,574, the increase being due to new connections, the number of premises supplied having increased from 387 to 505.

Hardness of the water from No. 1 bore 43·8°, from No. 2 46·4°. For analysis *see* p. 150.

4. Young & Co.'s Brewery.

Information from — THOMAS (1908).

Well 40 feet 10 inches (1¾ feet above ground-level, the rest bored).

		Thickness. Feet.
[Glacial Drift] 92 feet	Loam and sand	12
	Marl, with water	3
	Blue clay	32
	Hard dry clay (boring)	45

A great number of wells in Drift were recorded by F. J. BENNETT, the information being got from Mr. ALDRICH (marked Al.), G. BANHAM (G.B.), J. BANHAM (J.B.) and W. LIMMER (W.L.).

5. Foot of Denmark Hill. Mr. Ward's, mason (G.B.) Boulder Clay, no water, 29 feet.

Wells through Boulder Clay.

6. Cherry Tree Inn, near (G.B.). Boulder Clay, 36 feet. Sand 6. Water rose 4 feet.

7. Corn Hall, near (G.B.). Boulder Clay, to sand, 29 feet. Water rose 3 feet.

8. Denmark Hill, Easto's Soda Water Works (G.B.). Boulder Clay, to sand, 42 feet. Water rose 35 feet.

9. Dolphin Inn (Al.). Boulder Clay, 7 feet. Sand 4.

10. Greyhound Inn (J.B.). Boulder Clay. 52 feet. Sand 18.

11. Gurneys' Bank (Al.). Boulder Clay, to sand, 20 feet. Water rose 4 feet.

12. Heywood, north of the town, near Chapel Schools. (J.B.) Boulder Clay, to sand and water, 35 feet.

13. Highest part, near Brush Factory. (Al.). Boulder Clay, 40 feet. Sand 15.

14. Jarret's Farm. (J.B.). Sunk 50 feet, bored 25. Boulder Clay to sand. Water rose 30 feet.

15. Mr. Maling's. (Al.). Boulder Clay, to sand with water, 30 feet.

16. Mount Street, Mr. Garrod's (Al.). Boulder Clay, to sand, 50 feet. Water rose 3 feet.

17. Mount Street, Mr. Gilmans (Al.). Boulder Clay, to sand, 57 feet. Water rose 3 feet.

18. Mount Street, Miss Taylor's. Boulder Clay, to sand, 45 feet. Water rose 3 feet.

19. Murton's Farm (J.B.). Sunk 50 feet, bored 25. Boulder Clay, to sand. Water rose 30 feet.

20. St. Nicholas Street. (W.L.). Boulder Clay, 10 feet. Blowing sand 20.

21. Walcot Green (W.L.). Boulder Clay, 20 feet. Loam and blowing sand 21.

22. Walcot Green, Mr. Chase's (G.B.). Boulder Clay, 54 feet. Sand 4. Water rose 4 feet.

Wells in sand and gravel.

23. Chapel Street. Sand 25 feet.

24. Churchyard. (Al.). Sand 18 feet.

25. Denmark Green. Sand and gravel 8 feet.

26. Denmark Hill, opposite Easto's Soda Water Works. (G.B.). Sand 10 feet. Water rose 7 feet.

27. King's Head Hotel. (Al.). Sand, with shells and a tree-trunk, 15 feet.

28. Mere Street. (Al.). Sand 12 feet.

A letter from the Clerk to the Council, of Nov. 30, 1909, says that the gravel at Diss is in direct communication with the Chalk ; but the Chalk is drained upwards into the gravel, and not the gravel downward into the Chalk, as shown by the many springs that rise from the bed of the Mere.

Ditchingham.

Ordnance Map 176 (Norfolk 98, N.E.). Geologic Map 66, S.E.

1. Ditchingham House.

Communicated by Mr. LAWRENCE.

Water rather salt.

Clay and brickearth, about	36	76 feet.
Sand, a bed of shells 7 feet thick, without sand, at the base, about	40	

2. The Lodge. (D. PALMER.)

8 or 9 feet of hard shelly Crag met with.

3. Mrs. Menzies, ¼ mile north of Cold Bath House.

Communicated by Mr. LAWRENCE.

Clay	50	75 feet.
Sand	25	

At the base were found the following shells (in Mr. Hartcup's possession) :—*Purpura lapillus*, *Litorina litorea*, *Cardium edule*, *Mya arenaria*, *Tellina obliqua*, *T. prætenuis*, *Cyprina Islandica*.

4. Messrs. Rutter's new Malt Kilns, 1905 ?

Boring. Communicated by F. SMITH AND SON, of Grimsby.

Supply of 3,000 gallons an hour, rising to 2 feet below the ground. Quality very good.

		Thickness. Feet.	Depth. Feet.
Subsoil		1	—
[Drift and Crag?]	Rough gravel	15	—
	Silt (or silty sand)	50	—
	Fine sand, rather green	18	84
Chalk		110	194

5. Messrs. Mann's Maltings. 1901 ?

Made and communicated by MESSRS. LE GRAND AND SUTCLIFF.

About 16 feet above Ordnance Datum.

Water-level 2½ feet down.

		Thickness. Feet.	Depth. Feet.
[Drift and Crag.]	Sand and clay	3	—
	Sand and stones	22	—
	Green blowing sand	33	—
	Green blowing sand and shells, with 2 ins. of green rock at the top	30	—
	Green sand	11	—
	Flints	1	100
Chalk and flints		100	200

Docking.

Ordnance Map 130, new ser. (Norfolk 14, N.E.). Geologic Map 69.

Town well. Information obtained by G. BARROW (? 1883).

		Thickness. Feet.	Depth. Feet.
[Glacial Drift.]	Boulder Clay (known as brick-earth)	30 to 40	35
	Gravel	30 to 40	—
	Fine sand	70	140
Rock (very hard chalk)		50	190

The depth of clay and gravel together was said to be about 70 feet. The wel having gone dry some years ago was deepened, and on sinking 10 feet more they came on tabular flint, which crossed the entire bottom of the shaft. On breaking through this water came in and rose very rapidly, and the well has never been dry since. In April, 1883, there was 40 feet of water.

Another account got by C. REID says that the well is bricked for 60 feet, and that the rest is in chalk with flints to 216 feet. This, however, may refer to another well, as there are said to be two deep wells in Docking.

Downham Market.

Ordnance Map 159, new ser. (Norfolk 69, N.W.) Geologic Map 65.

1. Railway Station.

Communicated by MESSRS. TILLEY AND SON.

[Through clay] to a thin bed of rock with plenty of water.

2. Messrs. Wenn & Co., Brewers, &c.

Made and communicated by MESSRS. ISLER AND CO.

Lined with 70 feet of 4-inch tube.

Water-level 35 feet down. Yield 360 gallons an hour (from stone-beds?).

		Thickness. Feet.	Depth. Feet.
[Lower Greensand.]	Shaft (the rest bored)	—	7
	Dead sand	10	—
	Dead black sand	12	29
Kimeridge Clay, 187 feet.	Rock	2	—
	Blue clay	72	—
	Rock	6	—
	Blue clay	99	—
	Blue clay with stone	6	—
	Blue clay	2	216

Earsham.

Ordnance Map 176, new ser. (Norfolk 98, S.W. and S.E.).
Geologic Map 66, S.E.

1. The Hall.

Well sunk through clay, sand, and gravel, 74 feet to shells? (C. REID.)

2. Hall Farm.

Soil	1	92 feet.
Yellow loam	1½	
Blue clay and chalk	60	
Clay with Lias	6 or 7	
Blackish loamy sand	5 or 6	
Red gravel	7 or 8	
Black loam	10	

3. The Park.

Communicated by Mr. PALMER.

Boulder Clay	25	70 feet.
Sand and gravel	45	

4. Mr. Pipes, half a mile W.N.W of the Hall.

Communicated by Mr. LAWRENCE.

Chalky Boulder Clay	90	95? feet.
Sand, to water	4 or 5	

East Bilney, *see* Bilney.

East Carleton, *see* Carleton.

East Dereham, *see* Dereham.

East Harling, *see* Harling.

Easton.

Ordnance Map 161, new ser. (Norfolk 62, N.E.). Geologic Map 66, N.W.

New Rectory, E. of the church.

From F. J. BENNETT'S notes.

Gravel, to Boulder Clay, 30 feet.

East Rudham, *see* Rudham.

East Tuddenham, *see* Tuddenham.

Eccles.

Ordnance Map 175, new ser. (Norfolk 95, S.W.) Geologic Map 66, S.W.

By the Station.

Sunk and communicated by J. Banham, of Shelfhanger.

Sand, 15 feet.

Egmere.

Ordnance Map 130, new ser. (Norfolk 16, N.W.). Geologic Map 68, S.W.

Communicated by Mr. Massingham.

[Glacial Drift.]	A little sand	}	60 feet.
	Blue marly clay		

Ellingham (or Kirby Cane?).

Ordnance Map 176, new ser. (Norfolk 98, N.E.) Geologic Map 66, S.E.

Well described as in the parish of Hales, about a mile N.N.E. of Broome Place, by the side of the road from Bungay to Loddon, about a mile from Broome Church. This site is not in Hales, but in one of the above parishes, probably Ellingham, which place has nothing to do with the Great and Little Ellingham of the following entries.

Information from W. M. Crowfoot, 1903.—The boring when 150 feet deep was in estuarine Crag, a lead-coloured sand, full of shell-fragments, like the Crag that rests on the Chalk at the Beccles Waterworks. This went down to about 200 feet, when the clay was reached. A specimen from 206 feet down Mr. Crowfoot thought looked like London Clay (which he did not expect to find here), but to me it seemed more like Chillesford Clay.

Ellingham, Great.

Ordnance Map 161, new ser. (Norfolk 85, N.W. and S.W.). Geologic Map 66, S.W.

Crown Inn.

Sunk and communicated by — Pooley, of Besthorpe.

[Boulder] Clay, 37 feet.

Ellingham, Little.

Ordnance Map 161, new ser. (Norfolk 85, N.W.). Geologic Map 66, S.W.

Vineyard Farm.

Sunk and communicated by Mr. Pooley, of Besthorpe.

Glacial Drift	Red clay	2	}	12 feet.
	White clay	2		
	White sand	8		

Elsing.

Ordnance Map 147, new ser. (Norfolk 49, N.E.). Geologic Map 66, N.W.

1. Near the church.

Sunk and communicated by Mr. Thuxton.

Chalk, 20 feet.

2. To the west of Elsing Mill there is a well near the river, in the marsh-land, from which water is pumped up to Bylaugh Park. This well, I was told (on the spot), was sunk through the alluvial deposits into the Chalk, of which a considerable thickness was pierced, to a depth of 70 feet. I was unable to ascertain the thickness or character of the alluvial deposits passed through; but was informed that the supply of water from the Chalk not being found sufficient, water from the river was allowed to enter the well, and that this water was used.—J. H. Blake.

Fakenham.

Ordnance Map 146, new ser. (Norfolk 25, N.W and N.E.). Geologic Map 68, S.W.

1. Cemetery Road.

[Glacial Drift.]	Sand	35 feet.
	Brickearth (?)	

2. The Heath (1880).

[Glacial Drift.]	Soil and Chalky Boulder Clay... ... 7	50 feet.
	Loam 3	
	Sand ... ... about 40	

The wells on the heath vary from 45 to 60 feet in sand and gravel.

3. Norwich Street, Mr. Mansell's.

[Glacial Drift.] Clay and sand, 29 feet.

Chalk, in which water was obtained almost directly.

4. Sculthorpe Road, new cottages.

[Glacial Drift.]	Boulder Clay	40 feet.
	Sand	
Chalk		

5. Wells Road, Miss H. Rudge's, 1894.

Made and communicated by Messrs. Gidney.

Shaft 18 feet, the rest bored.

		Thickness Feet.	Depth Feet.
Made soil		3	—
Glacial Drift.	Grey sand	15	—
	Quick sand	8	—
	Gravel	18	44
Chalk and flints		25	69

Fincham.

Ordnance Map 159, new ser. (Norfolk 57, S.E., and 58, S.W.). Geologic Map 65.

Mr. Saunders' house. From C. Reid's Notes.

Boulder Clay, 10 feet, to Chalk.

Flordon.

Ordnance Map 161, new ser. (Norfolk 87, N.W. and S.W.). Geologic Map 66, S.E.

1. By Inn near Railway Station.

Information given by W. H. Lockwood.

Water got at the depth of 60 or 70 feet.

Boulder Clay.
[Crag.] Sand and gravel.
Chalk.

2. Flordon Hall.

Made and communicated by Messrs. Fake.

Old well (the rest bored) about 55 feet.
Blowing sand, 6 feet.
Very soft Chalk, to depth of 135 feet.

Fordham.

Ordnance Map 159, new ser. (Norfolk 69, S.W.). Geologic Map 65.

Ryston Railway Station.

[Boulder] Clay, 47 feet.

Forncett.

Ordnance Map 175, new ser. (Norfolk 86, S.E. and 96, N.E.). Geologic Map 66, S.E.

Hill House. 1905.

Made and communicated by W. G. FAKE (of Norwich).

Shaft 72 feet, the rest bored.

Good supply.

		Thickness. Feet.	Depth. Feet.
[Drift]	Blue clay	92	—
	Blowing sand	20	—
	Blue clay	5	—
	Shale and sheets [? laminated clay] ...	5	122
[Chalk]	Marl and flints	5	—
	Chalk	17	144

Foulsham.

Ordnance Map 147, new ser. (Norfolk 37, N.E. or 26, S.E.). Geologic Map 68, S.W.

1. Level crossing S. of Guestwick Station.

[Glacial Drift] { Grey Boulder Clay... ... ... } about 30 feet.
{ Slate-blue Boulder Clay ... ... }
Water.

Framingham.

Ordnance Maps 161, 162 (Earl F.) (Norfolk 76, S.W.). Geologic Map 66, S.E.

"Chalk found at a depth of about 30 feet in digging a well."—DR. RIGBY, Framingham, its Agriculture, &c., p. 47.

FRAMINGHAM PIGOT.—¼ mile N.N.E. of Gull Inn.

(H. B. WOODWARD'S Notes.)

Soil and chalky Boulder Clay ... ... } 62 feet
Sand and gravel ... ... }

Fundenhall.

Ordnance Map 161, new ser. (Norfolk 86, N.E. and S.E.). Geologic Map 66, S.W.

1. Cottages near the Hall.

Sunk and communicated by — POOLEY.

Sunk 40 feet, bored 30 feet.

(Boulder) Clay to sand, water rose 35 feet ... ... 70 feet.

2. Another well close by.

Sunk and communicated by J. BANHAM, as also the following two.

Sunk 30 feet, bored 25 feet, in black moory soil.

3. The Hall.

Sunk 50 feet, bored 30.

(Boulder) Clay, to sand and water ... ... 80 feet.

4. By the Church.

(Boulder) Clay ... ... 60 feet.

Garboldisham.

Ordnance Map 175, new ser. (Norfolk 104, S.W.). Geologic Map 50, N.W.

1. Flint Hall.

Sunk and communicated by — WARREN.

[Boulder] Clay ... ... 60 } 100 feet.
Chalk ... ... 40 }

Garboldisham—*continued.*

2. Uphall Farm. 1912.

A 4-inch boring, made and communicated by MESSRS. FAKE.

Rest-level of water 56 feet down.

Good supply of pure water.

		Thickness. Feet.	Depth. Feet.
Soil		3	—
[Glacial Drift]	Grey clay, with stones	40	—
	Red sand and gravel	13	—
	Flints	4	60
Chalk	Boring lined for 12 feet, the rest not	81¾	141¾

Gayton.

Ordnance Map 146, new ser. (Norfolk 34, S.W.). Geologic Map 65.

1. Lynn Waterworks. N. of Well Hall Lane, E. of road from Gayton to Grimston. 1898. Extended 1905?

About 132 feet above Ordnance Datum. Top of well 126.

Communicated by E. J. SILCOCK; from the *Lynn Advertiser*, 25th March, 1898; and from the Local Government Board.

Two wells of 6 feet diameter, 7 feet apart, and one of 9 feet diameter; all 100 feet deep and lined to the bottom. From the bottom of one a boring of 8 (? 11) inches diameter. From the bottom of the western of the two wells a heading was driven to the south for 153 feet, and another to the north for 213. (Another and later account gives the figures 160 and 240).

From the eastern well a heading was made in an easterly direction for 50 feet, when it was found (after a 14 days' test) that a million gallons a day could be got. To ensure this quantity in dry seasons the headings were extended; the eastern one to 300 feet. All are 100 feet down and 6 feet by 4. All the wells and headings are connected.

Rest-level of the water: lowest 79 feet down, highest 58.

Pumping-level of the water: lowest 96 feet down, highest 76.

The lowest figures occurred in 1914, when the water-level was less than ever before.

		Thickness. Feet.	Depth. Feet.
[Lower Chalk]	Chalk (wells)	100	100
	Hard grey chalk	16	116
[Gault]	Blue gault	21	—
	Coloured clay	5	142
[Lower] Greensand		18	160

The following particulars are from the Local Government Board Return of 1915, p. 73. These works supply (besides Lynn) parts of Bawsey, Leziate, Mintlyn, and West Lynn, and also, in bulk, to the Freebridge Lynn Rural District.

The average daily quantity supplied was 847,300 gallons, and 18,843 in bulk, or a total of 866,143.

The water is very pure. Hardness, total 14°, permanent 1·1°.

The following table is an illustration of the changes in water-level, over a period of 1¾ years. The figures of the left and middle columns stand for feet below the surface.

	1913.	1914.	
January	—	70·5	61·6 above Ordnance Datum.
February	—	70·3	61·75 ,,
March	—	70·	62· ,,
April	57·	67·2	64·84 ,,
May	60·	67·1	64·17 ,,
June	62·	69·3	62·75 ,,
July	65·	72·	60· ,,
August	69·	75·	57· ,,
September	72·5	79·8	52·34 ,,
October	73·	77·5	54·6 ,,
November	73·5	78·	54· ,,
December	71·2	78·6	53·5 ,,

Gayton—*continued.*

2. Workhouse. At the border of the parish N.N.E. of the church.

From G. B. FOLKES (October 10, 1898).

Well 76¾ feet deep. About 6½ feet above the level of the Lynn Waterworks, and about 550 yards from them.

The heavy pumping at the Waterworks, in the autumn of 1898, for the purpose of driving a heading, dried the Workhouse well, which had about 17 feet of water in it before.

On October 26 MR. FOLKES wrote that the pumping being stopped on Sunday, the water in the Workhouse well rose 3 feet.

A tracing from E. J. SILCOCK (of an earlier date) gives the following figures, in feet above Ordnance Datum :—

	Waterworks (trial-boring).	Workhouse.
Saturation-level, January 21, 1895	79½	85½
Lowest recorded saturation-level, November 3, 1893	65	70

At the first of the above dates MR. SILCOCK added that from the springs (westward) to the workhouse, there was a rise in water-level of 35 feet, in 1,250 yards.

It became a question whether the workhouse-drainage, which was taken into a dead well, might cause risk of pollution at the works.

Gaywood.

Ordnance Map 145, new ser. (Norfolk 33, S.W. and S.E.). Geologic Map 65.

1. The Hall. About 1850.

From information on the spot.—W.W.

[Lower Greensand] { Sand and carstone, about 30 feet. / Hard rock, 10 or 15 feet.

2. Site not given. C. B. ROSE, *Phil. Mag.* 1835, ser. 3, vol. vii, p. 175.

[Lower Greensand ?]	Sand	18	
Kimeridge Clay	Blue clay, 14 inches	—	50 feet.
	Laminated clay with septaria, nearly ...	31	

Geldeston.

Ordnance Map 176, new ser. (Norfolk 98, N.E., 99, N.W.) Geologic Map 66, S.E.

1. Mr. James Boggis' house, 1865.

Communicated by Mr. BOGGIS (from memory) to E. T. DOWSON.

Clay, varying from brown to blue...	20	33 feet.
Sand (white) with few stones	7	
Gravel with smallish stones	6	
Blue clay	?	

2. Mr. Crisp's Malthouse (No. 2), November, 1870.

Communicated by E. T. DOWSON.

	Feet.
Sand with fine subangular gravel, principally flint, one or two quartz pebbles	7
Stiff bluish-white clay containing a great many chalk-nodules and a few flints	2
Passing into a clay resembling it but with some sand	3
Dark red ferruginous gravel (subangular) containing principally smallish flints and a few quartz and quartzite pebbles	4

I saw some of the clay that was taken out.

Top of well about 10 feet above river.

3. Messrs. Dowson's Malthouse (No. 3), 1875.

Communicated by E. T. DOWSON.

We took a small quantity of sand with small rounded stones from bottom of well, at a depth of about 8 feet.

Top of well about 4 feet above water.

Geldeston—*continued.*

4. Hall Farm.

From C. REID'S Notes.

Clay	25	90 feet.
Sand and gravel	65	

5. Old Brewery.

Communicated by D. PALMER.

Well in 15 feet of gravel and sand, the bottom not over 4 feet above the river; water at 11 feet. Then bored 65 feet in bluish sand, no gravel or clay, 3 or 4 feet in white clay (chalk?). The total depth is 80 feet from the surface, not 84 feet as shown by the details. At first the water supply was 36 gallons per minute. The well is now disused, and I am told the supply failed.

Gillingham.

Ordnance Map 176, new ser. (Norfolk 99, N.W. and S.W.) Geologic Map 66, S.E.

1. Gillingham Thicks for the Gamekeeper's Cottage.

Communicated by E. T. DOWSON.

The information as to thickness of each deposit was obtained from Mr YOUELL, well-sinker, Beccles. I compared the difference of altitude between the shell-bed at Aldeby and the top of the well with aneroid, and found it about 80 feet.

Upper Glacial clay about	20	72 feet.
White sand	30	
Gravel	8	
Brickearth?, if brickearth at all, it is very sandy but contains mica	3	
Red sand, silt and gravel, and white sand, to water ...	8	
Black loam	3	

2. Keeper's House.

From C. REID'S Notes.

Clay (land-spring) ... ... 72 or 73 feet.

3. Mr. Marsh's.

Communicated by MR. PALMER.

Well 95 feet, 30 or 40 feet of clay, the rest sand.

4. Five chains W. of Toll-gate at eastern part of village (on old map). Information by E. T. DOWSON, who saw the material and obtained the thicknesses from MR. YOUELL.

	Feet.
Sand, brownish and almost pure	6
White, very chalky Boulder Clay (Upper Glacial, without doubt, according to appearance. It contains much flint and some foreign boulders, and an oyster-shell, which I have)	13
Blue clay containing chalk nodules was bored through. To all appearance like the Upper Glacial	6
Gravel from which water rose.	

5. Opposite Church. For Mr. Kenyon (of Gillingham Hall).

Made and communicated by MESSRS. FAKE (of Norwich).

[Soil]	Loam	2	13½ feet.
[Drift and Crag]	Loamy sand	2½	
	Sharp red sand	7	
	Small broken shells	2	

Gissing.

Ordnance Map 175, new ser. (Norfolk 105, N.E.) Geologic Map 50, N.W.

Two wells. Sunk and communicated by W. LIMMER.

1. The Rectory. Sunk 32 feet, bored 10. 2. At the Brook. In both water rose 20 feet.

[Boulder] Clay, to sand, 42 feet in 1, 30 in 2.

Great Ellingham, *see* Ellingham.

Great Melton, *see* Melton.

Great Snoring, *see* Snoring.

Great Ryburgh, *see* Ryburgh.

Guist.

Ordnance Map 147, new ser. (Norfolk 26, S.W., 37, N.W.) Geologic Map 38, S.W.

The Vicarage. 1911.

Boring, made and communicated by Messrs. Duke and Ockenden.

Tubes, of 4½ inches diameter, to 36 feet.

Water-level 41 feet down. Tested for 12 hours at 450 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil		1	—
[Glacial Drift]	Clay and stone	2	—
	Yellow marl	3	—
	Sand	5	—
	Sand and gravel	3	—
	Gravel	2	—
	Sand	1½	—
	White marl	18	—
	Flints	½	36
Soft Chalk		36	72

Haddiscoe.

Ordnance Map 162, new ser. Geologic Map 66, S.E.

South of the village (exact locality unknown).

Communicated by D. Palmer.

Well, 87 feet. 35 feet clay, the rest sand. 60 or 70 feet down came to large pieces of wood, said to be oak and alder.

Hales.

Ordnance Map 162, new ser. (Norfolk 89, S.W.) Geologic Map 66, S.E.

1. The Green.

Depth 60 feet. 30 feet clay. (D. Palmer.)

2. House at the middle part.

Measured by C. Reid.

Boulder clay	12	
Clean white sand without stones	22	
Brown loam with stones	5	
Chalky gravel with water...	2	59 feet.
Brown loam, with scattered stones and fragments of *Cyprina Islandica*	12	
Sand rather coarser than the Middle Glacial	6	

See also under **Ellingham.**

Hanworth.

Ordnance Map 131, new ser. (Norfolk 19, S.W.) Geologic Map 68, S.E.

The Hall. 1900?

Bored and communicated by MESSRS. MERRYWEATHER.

Water level 27 feet down.

Old well (the rest bored)	32	100 feet.
Running sand, to Chalk	68	

Hardwick.

Ordnance Map 175, new ser. (Norfolk 97, S.W.) Geologic Map 66, S.E.

Two wells, sunk and communicated by W. LIMMER.

1. The Hall. Water rose 15 feet. Blue [Boulder] Clay, to sand, 60 feet.

2. The Rose and Crown. Water rose 5 feet. Boulder Clay to Loam and sand 40 feet.

3. Another well at the Hall. From F. J. BENNETT'S Notes. Passed through 40 feet of clay.

Hargham.

Ordnance Map 175, new ser. (Norfolk 95, N.W.) Geologic Map 66, S.W.

Two wells, made and communicated by — LINCOLN, of Attleborough.

1. By the bridge at the four cross-roads.
Sand and then Boulder Clay, thickness doubtful.

2. The "Sheepwalks." Sand 6 feet.

Harleston.

Ordnance Map 175, new ser. (Norfolk 106, S.E.) Geologic Map, 50 N.E.

Five wells, sunk and communicated by W. LIMMER.

1. Eastern end of the town. Sand, 40 feet.

2. Market Place. Sand, 30 feet.

3. Malting by Railway Station. [Boulder] Clay, to sand, 45 feet.

4. By the Swan Inn. [Boulder] Clay, 30 feet. Sand, 10 feet.

5. White House. Water rose 4 feet. [Boulder] Clay, 5 feet. Gravel, sand and loam, 93 feet.

6. Dr. J. R. Robinson's (late Dr. Candler's) house. In the main street 200 yards S. of Railway Station.

Made and communicated by MESSRS. ISLER and Co. and from DR. CANDLER.

? About 180 feet above Ordnance Datum.

Lined with 50 feet of 6-inch tubes and 125 feet of 5-inch tubes.

Water-level 25 feet down. Supply 250 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)		—	30
[Glacial Drift]	Fine sand	10	—
	Coarse gravel. Flints and quartzite-pebbles	19	59
[Crag, 69 feet]	Green sand and shells	14	—
	Blue clay	4	—
	Grey sand and clay	5	—
	Grey loam and shells	5	—
	Grey sand and clay	41	128
[Upper] Chalk and flints		122	250

Harling, East.

Ordnance Map 175, new ser. (Norfolk 104, N.W.). Geologic Map 66, S.W.

In his Quarterly Report to the Public Health Committee of the Norfolk County Council (December, 1911), DR. J. T. C. NASH treats of the water-supply of this place and says, "Like many another village in Norfolk, East Harling has grown up on a large patch of sand and gravel overlying the chalk beneath. Such localities were chosen by our ancestors because of the ease of obtaining water from the sands by means of shallow wells."

"Unfortunately the abundant water found in such formations became gradually polluted through the inhabitants also sinking . . . cesspits and privies in the same sands . . . pits dug a few feet into the sands, with uncemented bottoms, the sands thus soaking up the liquid contents."

This practice has caused polluted water-supplies. "Where the sand is coarse or gravelly the pollution is more gross and dangerous. When the sand is very fine and compact, as is the case at East Harling, the water travels but slowly through it, and opportunity for greater oxidation and more effective relative purification is afforded."

The fine sand "has an average depth of 20 feet at East Harling . . . In the particularly fine filtering character of this sand may indeed lie the explanation of the remarkable freedom from disease which East Harling has enjoyed for many years. But freedom from disease for years does not in itself justify the continued use of a water which is potentially dangerous."

Several tube-wells have recently been driven, through the Drift into the Chalk, "which have tapped a plenteous supply of potable water."

At the Police Station are two of these, "to 100 feet (one having buckled) without striking water, yet next door . . . there is a tube well which delivered water at 90 feet. This well was driven further to 192 feet, or about 80 feet into the chalk."

The Thetford Rural District Council has had 38 borings made. "These wells are driven from 40 to 80 feet into the chalk, or to a total depth of over 100 feet."

"Since the tube wells have been sunk . . . tapping a pure chalk water, the water supply of the village as a whole is now better than in the majority of other villages in the County."

Hedenham.

Ordnance Map 176, new ser. (Norfolk 98, N.W.). Geologic Map 66, S.E.

1. Brick Kiln.

Communicated by D. PALMER.

30 feet clay and 30 brickearth. Total 60 feet.

[Probably incorrect.—C. REID.]

2. House of Mercy.

2-4. Measured by C. REID.

Loam	5 or 6	60 feet.
Gravel and sand	55	

3. Mr. Moore's.

Clay [boulder clay]	50	77 feet.
Finely laminated brickearth	20	
Sand	7	

4. Rectory.

Ferruginous pebbly gravel	15	39 feet.
Loam	4	
Stony brickearth	4	
Shingle and sand	16	

Hellesdon.

Ordnance Map 161, new ser. (Norfolk 63, N.W.). Geologic Map 66, N.E.

Asylum, on the high road north of the village.

From H. B. WOODWARD'S Notes.

Water-level stands at about 70 feet down : all sunk.

[Lower Glacial.]	Brickearth	6	75 feet.
[Crag.]	Gravel and sand	24	
Chalk		45	

From a later note (1906). Well 90 feet and then an 11-inch boring (with tube) 60. Yield 16,000 to 17,000 gallons in 24 hours ; affected by rainfall and drought. The water contains nitrates and nitrites.

Hempnall.

Ordnance Map 175, new ser. (Norfolk 87 S.E. and 97 N.E.). Geologic Map, 66 S.E.

The Green.

Communicated by MR. PALMER.

Depth 70 feet. 30 or 40 feet clay.

Hemsby.

Ordnance Map 148, new ser. (Norfolk 54 N.W. and S.W.). Geologic Map, 67 N.

1. Brickyard, $\frac{3}{8}$ mile S.S.W. of the Church.

[Glacial.] Loam, unstratified and mottled grey and brown, with a little grey clay at the base, and then sand, 14 feet.

2. About 12 chains N. of the Church. 1878.

[Glacial Drift.]	Loamy clay, mottled brown and grey ...	11	16+ feet.
	Buff sand (patch in clay probably)... ...	5	
	Grey loamy clay	?	

3. Near railway-bridge, $\frac{3}{4}$ mile W. by N. of the Church.

Water rose 5 feet.

[Glacial Drift.] Reddish brown loamy clay, 16 feet.

Henstead Rural District.

According to Reports of the Medical Officer the supply is from wells, both shallow and deep. Parts of Trowse Newton and Cringleford get their supply from the Norwich Co.'s mains and some houses in Whitlingham from a deep well on the Whitlingham Farm, of the Norwich Corporation.

Hethel.

Ordnance Map 161, new ser. (Norfolk 74 S.E., 75 S.W., 86 N.E., 87 N.W.). Geologic Map 66 S.E.

Parsonage.

Sunk and communicated by JAMES BANHAM.

Boulder Clay (water rose 8 feet) ... ... 45 feet.

Hilborough.

Ordnance Map 160, new ser. (Norfolk 71 S.W.). Geologic Map 65.

The House. From A. C. G. CAMERON'S Notes.

Gravel	3	45 feet.
Blue [Boulder] Clay	42	

The garden-well is also through 42 feet of blue clay, and the water rises to 10 feet from the surface.

The well at the Post Office is 21 feet deep, through Boulder Clay or brick-earth.

Hillington.

Ordnance Map 146, new ser. (Norfolk 23 S.W.). Geologic Map 69.

Railway Station, 1915.

Made and communicated by MESSRS. FAKE, of Norwich.

Good supply, of excellent quality.

	Thickness. Feet.	Depth. Feet.
Sand	14½	—
Blue clay	15	29½
Marl and stones	45	—
Chiefly blue clay	55½	—
Cobble (? rubble) chalk	5	—
Blue-grey clay	35	170
Chalk	13	183

This section cannot be interpreted. The site seems to be on the Gault.

G. W. LAMPLUGH.

Hockham.

Ordnance Map 174, new ser. (Norfolk 94 N.E.) Geologic Map 66 S.W.

In the village.

Sunk and communicated by — LINCOLN, of Attleborough.

Gravel	2	22 feet.
[Boulder] Clay	20	

Hockwold.

Ordnance Map 174. (Norfolk 92, S.W.) Geologic Map 65.

The Hall, 1899.

Communicated by DR. J. C. THRESH, from particulars given by MESSRS. LE GRAND & SUTCLIFF, 1899.

Lined with steel tubes to 95 feet. 4-inch boring.

Water enters between 95 and 107 feet down. Water-level 15½ feet down. Supply about 700 gallons an hour.

		Thickness. Feet.
Mould		1
Chalk 124 feet	Chalk and flints	23
	Mottled clay	9
	Hard chalk, no flints	74
	Light-blue clay	8
	White clay	10

There are no surroundings likely to affect the character or purity of the water for an analysis of which *see* p. 154.

The occurrence of clay-beds in the Chalk is peculiar: perhaps they may be merely very soft chalk, what is called "putty chalk" in some sections. PROF. P. G. H. BOSWELL, in *Journ. Ipswich Field Club*, vol. v, pt. i, p. 21, gives this merely as white clay 125 feet, ? chalk not reached. I take it that white clay = clayey chalk.

Holkham.

Ordnance Map 130, new ser. (Norfolk 8, N.W.). Geologic Map 68, S.W.

HOLKHAM HALL, 1867.

Communicated by Mr. SHELLABEAR, Agent to the Earl of Leicester. *Proc. Norwich Geol. Soc.*, vol. i., pp. 16–18.

Thirty feet above mean sea-level. Shaft 58 feet, the rest bored. Supply abundant, 540 gallons a minute have been pumped. Overflow of 100 gallons a minute passes off by a pipe 14 feet below the floor, but when this is closed the water rises to the surface.

		Thickness. Feet.	Depth. Feet.
Gravel ... ... about		20	—
Chalk, 635 feet	Chalk with flints; the last of three masses of flint, each 3 to 4 feet thick, at a depth of 510 feet	519	539
	Chalk without flints	116	655
Red marl ["Red chalk"]		8	663
Blue gault, like that in Colman's well, Norwich ...		10	673
Neocomian, 70 feet	Very hard red sandstone	½	—
	Sandstone	14½	—
	Green sand	8	—
	Sand?	39	—
	Soft carstone	3	—
	Hard carstone	5	743

To very tenacious clay [Kimeridge or Neocomian?].

Holkham—*continued.*

Another account of this well was published by C. B. Rose (*Geol. and Nat. Hist. Repertory*, 1869, p. 257).

Commenced October, 1864, completed August, 1866. First 29 feet dug, with diameter of 6 feet, the rest a 6-inch bore.

	Thickness. Feet.	Depth. Feet.
Sharp small gravel and shingle	27	—
Chalk rubble	2	29
Chalk with flints	510	539
At this depth, 510 feet, there "occurred two other beds above the bottom one, separated from each other by only 6 inches of chalk, whilst, as is usually the case, the beds of flint recurred at spaces varying from 3 to 6 and 8 feet."		
Chalk without flints (including bed of hard grey chalk)	145	684
Red chalk, with varying degrees of colour	8	692
Blue gault	10	702
Reddish-brown ferruginous sandstone	8	—
Dark coloured "carstone"	6	716
Loose sand, to Kimeridge clay	36	752

Holt.

Ordnance Map 131, new ser. (Norfolk 10, S.W., 18, N.W.). Geologic Map 68 S.W.

1. Brewhouse.

[Glacial Drift]	Gravel (sunk)	60	150 feet.
	Marl (bored)	90	

2. Lion Inn.

Water from sand beneath the marl? (C. Reid.)

Sunk...	99	148 feet.
Bored in marl?	49	

3. Waterworks. Trial Bore Hole at Spouts Common.

Communicated by E. Easton. 1883.

135·1 feet above Ordnance Datum. Dug 7½ feet (the bottom 1½ filled up). The rest bored.

Water-level, June 20, about 69½ feet down; August 15 (1883?).

		Thickness. Ft.	In.	Depth. Ft.	In.
Topsoil and peat		1	6	—	
[Glacial Drift]	Beach sand and pebbles	11	0	—	
	Brown sand	4	0	—	
	White clay	23	6	—	
	Light-blue marl	21	0	—	
	Dark blue marl, with sand	10	0	—	
	Sandy clay, with very minute stones ...	16	0	—	
	Sandy clay, with chalk	19	0	—	
	Soft clayey chalk [may be part of very chalky Boulder Clay or Marl] ...	8	9	114	9
Chalk. Layers of flints at top and at 175 and 187 feet		102	9	217	9

4. Gresham Schools. On the Cromer road, half a mile N.E. of the town. 1907.

Bored and communicated by Messrs. Duke and Ockenden.

Lining tubes of 10 inches diameter to 187 feet. Then a perforated tube of 7 inches diameter to the bottom.

Water-level 58 feet down. Yield 3,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	Gravel	35	—
	Plastic clay	103	—
	Clay and flints	22	160
[Upper] Chalk		92	252

Holt—*continued.*

5. The Schools. Rev. — Lloyd. Near the Gresham School. 1905.

Bored and communicated by Messrs. Duke and Ockenden.

		Thickness. Feet.	Depth. Feet.
Soil		2	—
[Glacial Drift]	Very rough gravel	8	—
	Coarse red sand	½	—
	White sand, very dry	1½	—
	Coarse yellow sand	2	—
	White sand, few stones	6	—
	Coarse yellow sand, few stones	6	—
	Boulder gravel	5	—
	Yellow sand, with stones	9	—
	White plastic clay	2½	—
	Light-coloured running sand	12	—
	White and grey plastic clay	111½	166
	Green flints	6	—
	Sand and stones, pebbly	4	—
	Green flints	5	181
[Upper] Chalk		39	220

The water very soft. For an analysis *see* p. 155.

Honingham.

Ordnance Map 161, new ser. (Norfolk 62, N.E.). Geologic Map 66, N.W.

The Hall.

Driven tube-well, made and communicated by Messrs. Gidney.

		Thickness. Feet.	Depth. Feet.
Made soil		3	—
Blue [Boulder] clay		20	23
[Glacial Sand and Gravel]	Gravel	15	—
	Light-coloured sand	10	—
	Quick sand	9	57
[Upper] Chalk and flints		11	68

Another boring, made and communicated by Messrs. Fake. 1912. Four inches diameter, lined with tube for 75 feet.

Water rose to 5 feet 2 inches from the top.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	Loamy sand	4	—
	Grey clay	4	—
	Rough sand and fine shin [?]	27	—
	Marl and flint-stone	7	—
	Yellow marl	3	—
	Soft mallgean [?] marl	10	55
[Upper Chalk]	Close hard chalk. Flint-floors at 72 and 84 feet	30	—
	Good chalk. Flint-floors at 93, 98, 108, 117, 126, 130 to 134, 148 and 167 feet	91⅔	176⅔

Floors of flint also said to occur at 27 and 38 feet.

Horsey.

Ordnance Map 148, new ser. (Norfolk 41, S.E., and 42, S.W.). Geologic Map 67, N.

On marsh, ¾ mile S. of the church, and about 150 yards, or more, eastward of the road.

[Alluvial and Estuarine Deposits.]	Black ooze and silt, with a bed of shells 6 feet down, and a trunk of oak at 10 feet	19	20 feet.
	Sand	1	

Horsford.

Ordnance Map, 147, new ser. (Norfolk 51, N.W. and S.W.). Geologic Map 66, N.E.

I was told that the well at the mill, Horsford Heath, was sunk through more than 40 feet of brickearth, the lower part of which was full of "dodmans," bits of marl or chalk.—H. B. WOODWARD.

Ickburgh (or Ickborough).

Ordnance Map 174, new ser. (Norfolk 83, S.W.). Geologic Map 65.

Ickburgh Camp, 100 yards S.S.E. of the church and eastward of Manor Farm. 1916. 55 feet above Ordnance Datum.

Communicated by the WAR OFFICE, and by MESSRS. DUKE AND OCKENDEN.

Lined with 10-inch tubes to 39 feet.

Rest-level of water 40 feet above Ordnance Datum.

Yield 800 gallons an hour. Found by continuous pumping for a day. Pumping went on practically every day since the boring was finished, 13th May, 1916, until 4th October.

Sandy soil		1½	
Chalk	Marl and flint	18½	49 feet.
	Chalk and flint	18½	
	Hard flinty crust	1½	
	Water-vein	9	

Ingham.

Ordnance Map 148, new ser. (Norfolk 41, N.W.). Geologic Map 68, E.

New Hall, N. of the village. 1907.

Made and communicated by MESSRS. ISLER & Co.

Lined with 10 feet of 6-inch tubes and 60 feet of 5-inch tubes.

Supply, small.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	Loamy clay	11	—
	Blowing sand	20	—
	Ballast [gravel]	1	—
	Loamy clay	15	—
	Grey sand	8	—
	Loamy clay	6	—
	Grey sand	12	73
[? Crag]	Light-blue clay	3	—
	Grey sand and shells	9	—
	Blue clay	2½	87½

Work begun 11 March. Finished in May.
Classification suggested by PROF. P. G. H. BOSWELL.

King's Lynn, *see* Lynn.

Kirby Bedon.

Ordnance Map 162, new ser. (Norfolk 76, N.W.). Geologic Map 66, N.E.

1. Well at cottage by junction of lanes north-east of Church.

From H. B. WOODWARD's Notes.

Chalky Boulder Clay...		20	53 feet.
[Norwich Crag.]	Gravel and sand	33	

2. Well yielding a very peculiar water, *see* p. 156.

F. SUTTON, *Trans. Norf. Nat. Soc.*, 1885, vol. iv., pt. i, p. 45.

[Boulder Clay]	Grey clay...	20	
	Blue clay...	60	
[Crag] ...	Bright sand	25	110 feet.
	Iron-pan	4	
	Mixed sand and blue clay	1	

Kirby Cane.

Ordnance Map 176, new ser. (Norfolk 89, S.W. 99, N.W.). Geologic Map 66, S.E

Farm 30 chains N. of the Church.

Measured by C. Reid.

Clay, with chalk, flints, &c.	40	
Sand, fine white	8	
Stony clay	9	
White sand, with a few pebbles and occasional pieces of clay	18	
White sand, more pebbly	2	
Brickearth, with small pieces of chalk	1¼	111 feet.
Sand, with scattered stones, as above	2	
Brickearth, with scattered stones, angular, sub-angular, and pebbles, no bedding	10	
Sand, with occasional balls of blue loamy clay (sand evenly bedded)	1	
Pebble gravel	19¾	

See also under **Ellingham.**

Langley.

Ordnance Map 162, new ser. (Norfolk 76, S.E.). Geologic Map 66, S.E.

The Park. 1892?

Made and communicated by Messrs. Gidney.

		Thickness. Feet.	Depth. Feet.
Old shaft (the rest bored)		—	85
[?Glacial Drift.]	Quick sands	15	—
	Gravel	8	—
	Dark clay...	68	—
	Sandy clay	29	205
[Crag]	Dark sand and small shells	15	220
[Upper]	Chalk, with thick flints...	20	240

It seems doubtful whether the Drift goes to so great a depth. Perhaps some of the clay is Chillesford Clay. Another version gives sand and shells up to clay at 161 feet, thus carrying the Crag higher, and makes the depth to Chalk about 197 feet.

Langmere Green, *see* Dickleburgh.

Lexham (East).

Ordnance Map 146, new ser. (Norfolk 47, N.E.). Geologic Map 65.

Lexham Hall. 1892?

Made and communicated by Messrs. Gidney.

Old shaft (the rest bored)...		28	
[Glacial Drift]	Brown sand...	6	108 feet.
	Blue clay	65	
	Chalk-stones	9	

Litcham.

Ordnance Map 146, new ser. (Norfolk 48, N.W.). Geologic Map 66, N.W.

North of Beck's Farm.

From H. B. Woodward's Notes.

Coarse (Plateau) Gravel, 12 feet.

Little Ellingham, *see* Ellingham.

Little Massingham, *see* Massingham.

Little Plumstead, *see* Plumstead.

Loddon.

Ordnance Map 162, new ser. (Norfolk 88, N.E.). Geologic Map 66, S.E.

Dr. S. M. Copeman's Report to the Local Government Board, 1895, No. 95, pp. 1, 2.

"Drinking water is entirely obtained from surface wells, of which there are from 60 to 70 in the town. In the majority of these the depth of water does not exceed 4 feet. The water of the wells in that part of the town which lies between the Green (one of the highest parts) and the river, appears to be of universally bad quality, owing probably in a large measure to long-continued contamination of the subsoil in that part of the town most remote from the river; and to the south of the Green the water, which in like manner is obtained from surface wells appears, as far as can be gathered from the simple tests that have been employed, to be of somewhat better quality than is the case in the northern part of the town. But not only is the quality of the water generally bad, but the quantity is apt to be decidedly insufficient for the wants of the inhabitants, especially in times of drought." The wells must be in the Norwich Crag. For analyses of the waters *see* p. 157.

Apparently something has been done to remedy defects, as in the Local Government Board Return of 1915, p. 473, the supply is noted as good.

Long Stratton, *see* Stratton.

Lyng.

Ordnance Map 147, new ser. (Norfolk 49, N.E., and 50, N.W.) Geologic Map 66, N.W.

Lyng High House, a mile and a quarter S.E. by S. of the Church.

Boulder Clay, to sand and water, 60 feet.

36 cattle, suffering with the plague, were killed in 1865, and are said to have been buried in the sand at the bottom of the pit about 150 to 180 yards distant.

Lynn.

Ordnance Map 145, new ser. (Norfolk 33, S.W.). Geologic Map 65.

Mr. Allen's. Nearly opposite St. Nicholas Church. ? About 1812.

C. B. Rose. *Phil. Mag.*, ser. 3, vol. vii., p. 174, and *Geologist*, 1843, p. 76. In the Fenland Memoir p. 270, there is an error in the thickness given to the last three beds.

? Shaft 450 feet, the rest bored [Letter from S. Smith.]

	Thickness. Feet.	Depth. Feet.
Soil. [In an account lent me by Mr. Russell, of Lynn, got from the man who made the well, this was 7 feet.—W.W.]	—	—
[Alluvium] Loam [silt]	7	—
[Alluvium] Peat	2 to 2½ (or 3 ?)	—
[Alluvium] Blue clay...	8	—
[Alluvium] Peat, with alder and hazel	2 to 3	20
[Alluvium] Blue clay, with marine silt and shells ...	about 30	50
Blue clay, inclosing nodules of chalk [Boulder Clay]		
Oxford Clay, with septaria, &c. [The upper part certainly, and perhaps the whole is Kimeridge clay.—S. B. J. Skertchly.]	630	680

Waterworks, *see* Gayton.

These supply also part of West Lynn.

Marham.

Ordnance Map 160, new ser. (Norfolk 58, N.W.). Geologic Map 65.

Cottages, on the southern side of the lane five-eighths of a mile S. of the church, and N.E. of the Lime-kiln. Some years ago.

From a letter, by the REV. H. J. SHARPE dated March 1887.

Sunk through Chalk [Middle ?, and Lower]	85	115 feet
Bored through Clay [Gault ?]	30	

Whether sand was reached or not could not be said; but the water became troublesome, and the work was stopped.

Marlingford.

Ordnance Map 161, new ser. (Norfolk 62, S.E.). Geologic Map 66, N.W.

For Mr. E. B. Fletcher. 1884.

Made and communicated by MESSRS. LE GRAND AND SUTCLIFF.

Water-level, 45 feet down.

		Thickness.	
[Glacial Drift.]	Loamy sand	4	114 feet.
	Clay and sand	7	
	Light-coloured clay	2	
	Light-blue clay	4	
	Black peat	10	
	Drift (Boulder Clay)	61	
	Sand and clay	19	
	Gravel	2	
	Sand	1	
	Gravel	4	

Marsham.

Ordnance Map, 147, new ser. (Norfolk 37, N.W.). Geologic Maps 66, N.E., 68, E.

Rippon Hall.

Communicated by F. SUTTON.

Lower Glacial	Loose sandy gravel	6 to 8	? 43 feet.
	Brickearth	25	
Upper Crag.	Contorted sands and gravel, to Chalk	10 to 12	

Marshland.

Of this large tract DR. J. T. C. NASH says, in his Report to the County Council for 1914, p. 28: "An increasing area of the district receives an ample supply of excellent water from the Wisbech mains, but nearly one-half is still dependent on cisterns and shallow wells, which fail to meet the demand when there has been a few weeks' drought. The quality of the water also frequently leaves much to be desired."

Martham.

Ordnance Map 148, new ser. (Norfolk 53, N.E., and 54 N.W.). Geologic Map 67, N.

At level crossing close to the railway-station.

[Glacial.]	Brown loam	21	23 feet.
[Pebbly Series.]	Sand. Water got at the bottom ...	2	

At the next two level crossings the wells are 30 feet and 13 feet respectively in depth, mostly through Lower Glacial loam into the underlying sand.

Massingham, Great.

Ordnance Map 146, new ser. (Norfolk 35, N.W.). Geologic Map 69.
Iron Works, near the Vicarage. 1912.

Shaft throughout, made by J. H. CORNISH, and communicated by his manager, F. H. WILD.

Water suddenly burst through, in the night, and rose 75 feet.

		Thickness. Feet.	Depth. Feet.
Alluvium		5	—
[Boulder Clay.]	Brick-earth	6	—
	White clay, with few flints	30	—
	Blue clay, with chalk-stones and flints	107	148
Hard black clay		2	150

MR. WILD also reported that within about 60 yards is a well at the vicarage, about 100 feet deep, sunk through hard chalk, stone-built only 30 or 40 feet down. The water-level practically the same as at the above.

According to W. L. SUTTON a well at Massingham House, 142 feet deep, gave a yield of 410 gallons an hour.

In the Annual Report of the County Medical Officer for 1914, DR. J. T. C. NASH says that this place "has not yet been able to secure a pure supply from the new well (150 ft. deep), all analyses showing it to be highly polluted, and it is probable that the spring is contaminated by the presence of another deep well some 400 yards away, which it is found has been used as a cesspool for years."

Massingham, Little.

Ordnance Map 146, new ser. (Norfolk 35, N.W.). Geologic Map 69.

Brickyard, south of the church, made in 1882, and communicated by J. SEAMAN, of Great Massingham.

Clay, light-coloured at top, the rest blue [Loam and Boulder Clay	100	130 feet.
Chalk	30	

Melton Constable.

Ordnance Map 147, new ser. (Norfolk 17, S.E.). Geologic Map 68, S.W.

Midland and Great Northern Railway Station.

Made and contributed by MESSRS. LE GRAND AND SUTCLIFF.

272 feet above Ordnance Datum.

Lined with steel tubes of 11½ inches internal diameter to 230 feet.

Water-level, 23 feet down. Yield copious, but no prolonged test had been made

		Thickness. Feet.	Depth. Feet.
Soil		6	6
[Glacial Drift.]	Loam, clay and stones...	2½	—
	Loam	7	—
	Sandy ballast [gravel]...	6½	—
	Sandy ballast and chalk	8½	—
	Coarse ballast	12	—
	Brown loam	9½	—
	Clay, sand and chalk	8	—
	Clay and sand	4	—
	Clay, loam, sand, flints, chalk and pebbles	13	—
	Clay and sand	9	—
	Chalk marl and flints	5	—
	Hard sand	14	—
	Sand, flints and chalk	15	—
	Clay, chalk and stones...	3	—
	Clay, stones, chalk and sand	47	—
	Flints and sand...	5	175
Chalk and flints		301	476

An account of an older well (?) at this station is as follows:—[Glacial Drift] Sand and brick-earth, with nests of sand, to Marl, 30 or 40 feet.

Melton, Great.

Ordnance Map 161, new ser. (Norfolk 74, N.E.). Geologic Map 66, N.W.

In village.
Sunk and communicated by — THUXTON.
Boulder Clay, to sand, 20 feet.

Merton.

Ordnance Map 160, new ser. (Norfolk 84, N.W.). Geologic Map 66, S.W.

1. Broomhill Farm (wrongly entered as Broom Hill, Watton, in The Summary of Progress for 1910, p. 76, in which the section was published).

Made and communicated by MESSRS. ISLER AND CO.
Well 6 feet, the rest bored.
Lined with 20 feet of 5-inch tubes 6½ feet down, and 250 feet of 4-inch tubes 6 feet down. Tubes since raised 5 feet.
Supply 460 gallons an hour. Water charged with iron.

		Thickness. Feet.	Depth. Feet.
Mould		3	—
[Glacial Drift]	Sand and ballast [gravel]	4	—
	Ballast	8	—
	Loam	5	—
	Blue silt	65	—
	Fine grey sand	30	—
	Conglomerate	6	—
	Fine grey sand	16	—
	Conglomerate	4	—
	Fine grey sand	10	151
[Upper]	Chalk and flints	155	306

This section agrees with neighbouring sections at Saham Toney (*see* p. 115) in showing an unexpected great depth of Drift.

2. The Hall.

Sunk and communicated by — POOLEY, of Besthorpe.

(Boulder) Clay	5	115 feet.
Marl	10	
Chalk	100	

Metton.

Ordnance Map 131, new ser. (Norfolk 19, N.W.). Geologic Map 68, E.

? for Cromer Waterworks. Trial-boring.

C. REID. *Trans. Norfolk Nat. Soc.*, vol. vii., pp. 297, 298. From samples sent by J. C. MELLISS.
118 feet above Ordnance Datum.
Yields abundance of good water.

		Thickness. Feet.	Depth. Feet.
Soil		1	—
Glacial Drift	Gravel	5	—
	Boulder Clay	24	—
	Sand and Boulder Clay	20	50
Forest Bed	Coarse blowing sand, pebbles, green flints and shells (*Cardium edule*, *Tellina balthica*)	11	61
Weybourn Crag and Chillesford Clay	Fine running sand and stones, with various marine shells	10	—
	Running sand, with veins of fine micaceous clay and pebbles	34	—
	Shells and green-coated flints, with various marine shells	1	106
Upper Chalk (said to be 60 feet, in the well)		60	166

The clay which seems to represent the Chillesford Clay here lies between two beds of shelly Crag. The names of the shells are given.
Well said to yield 2,000,000 gallons a week, with nine hours pumping a day.

Middleton.

Ordnance Map 145, new ser. (Norfolk 46, N.E.). Geologic Map 65.

Within 50 yards S.S.E. of the Hall. 1905.

About 110 feet above Ordnance Datum.

Made and communicated by MESSRS. LE GRAND AND SUTCLIFF.

Water-level 52 to 54 feet down.

		Thickness. Feet.	Depth. Feet.
Well (? old.	The rest bored)...	—	35
[Glacial Drift]	Loamy brown sand	6	—
	Sandy blue clay, with stones and sandstone	9	—
	Coarse loamy gravel, with sand ...	10	60
[Lower Greensand, 74½ feet]	Dark grey sand	24	—
	Dark green sandy clay	1	—
	Green sand	5	—
	Grey sand	16½	—
	Light-coloured sandstone	½	—
	Dark green sandy clay	6	—
	Dark green sandy clay and bands of stone	8	—
	Grey sand	11½	—
	Sandstone (specimen contains pebbles of black phosphate and lydite, a fragment of Belemnite and a piece of shell (G. W. LAMPLUGH)... ...	2	134½
[Kimeridge Clay]	Dark blue sandy clay	?	—

Mileham.

Ordnance Map 146, new ser. (Norfolk 36, S.W.). Geologic Map 66, N.W.

From H. B. WOODWARD's Notes.

Wells 15 to 40 feet deep. Water generally good.

Mitford *and* Launditch Rural District.

According to the Report of the Medical Officer, 1912, the water-supply is got almost wholly from shallow wells, that is, wells sunk down to the Boulder Clay, to form a receptacle for the water in the soil above that clay.

Morley (? *St. Botolph* or *St. Peter*).

Ordnance Map 161, new ser. (Norfolk 85, N.E.?). Geologic Map 66, S.W.

Information from H. W. GOLDING, 1909.

[Boulder Clay]	Loamy clay, 12 to 18 feet.	
	Stiff blue clay, with small lumps of chalk, from which water percolates in, but disappears in dry weather.	

Morning Thorpe.

Ordnance Map 175, new ser. (Norfolk 87, S., and 97, N.) Geologic Map 66, S.E.

Boyland Hall (from D. PALMER).

Well 40 or 50 feet, of which 20 feet is clay [Boulder Clay, at top].

Mundesley.

Ordnance Map 132, new ser. (Norfolk 20). Geologic Map 68, E.

Waterworks. In the valley, near Frog's Hall, 1898.

About 70 feet above the sea.

Made and communicated by MESSRS. MERRYWEATHER, and from specimens.

C. REID, *Trans. Norf. Nat. Soc.*, vol. vii., pp. 290–294.

The following is from the trial-boring, with the addition, in brackets, of notes of samples got by C. Reid during the sinking of the well.

		Thickness. Feet.	Depth. Feet.
Soil.	Loam and small stones	3	—
Contorted Drift.	Yellow loam and small stones	26	—
	Greyish chalky loam	11	40
Second Till.	Lead-coloured clay and flints	10	50
Arctic Freshwater Bed.	Flints, etc.	1	51
	Pebbly greenish sand	4	—
	(Laminated loam, full of mosses, and leaves of Arctic plants) about ...	4?	59?
Forest Bed.	Large flint	2?	—
	Loamy pebbly sand (lignite and coarse gravel of flint and clay-ironstone. Fragments of bone)	10	71
Chillesford Clay and Weybourn Crag.	Laminated micaceous silt (with *Scrobicularia* and *Hydrobia ulvæ*) ...	19	—
	Gravel of flint, quartz, quartzite, ironstone, pyrites, etc.	5	—
	Gravel (fragments of *Tellina balthica*, apparently from this part of the well)	2	97
Upper Chalk	Soft, usually grey-mottled. Flints at 120, 160, 161, 190, 200 feet. *Ostrea lunata* plentiful down to 150 feet	103	200

In the well Chalk was reached at a much higher level, though it is close by. The highest sample sent by the foreman was marked 89 feet, and a flint-bed occurred at 90 feet. The boring may have hit on a channel cut in the Chalk in Pliocene times.

Details of the fossils found are given in REID'S paper.

For an analysis of Mundesley water *see* p. 158.

Narborough.

Ordnance Map 160, new ser. (Norfolk 46, S.E.). Geologic Map 65.

Narborough House. 1884.

Made and communicated by MESSRS. LE GRAND AND SUTCLIFF.

Bored throughout. Water-level 8½ feet down. Supply good.

		Thickness. Feet.	Depth. Feet.
Chalk, moderately hard, and hardest near the base; with much water		85	—
Blue hard clay or marl [Gault]		20	105
[Lower Greensand 48 feet].	Sand. Specimen of coarse green sand at 113, with much water	12	—
	Green sand and pyrites	27	—
	Blowing sand and small white pebbles [? phosphatic nodules]	2½	—
	Blowing sand	6½	153

A. J. JUKES-BROWNE remarks that the hardest chalk, at the base, is probably the same bed as the hard whitish limestone of the Sow's Head Spring, Grimston, and of Shouldham

Needham.

Ordnance Map 175, new ser. (Norfolk 108, S.W. and S.E.). Geologic Map 50, N.E.

Wood Farm. 1889.

Bored and communicated by MESSRS. ISLER AND CO., and from specimens sent by them.

Lined with 215 feet of 4 inch tubes.

Water-level, 78 feet down. Supply 630 gallons an hour.

		Thickness. Ft.	In.	Depth. Ft.	In.
[Glacial Drift, 103 feet].	Yellow clay (weathered Boulder Clay)	2	6	—	
	Chalky Boulder Clay	31	6	—	
	Chalk, &c.	4	0	—	
	Sand and gravel	21	0	—	
	Chalky Boulder Clay	13	5	—	
	Gravel and sand...	10	5	—	
	Bluish Loam (? Lower Boulder Clay)	4	0	—	
	Gravel (quartzose)	13	0	—	
	Dark brown or blackish micaceous clay, with specks of vivianite (Lower Boulder Clay) ...	4	2	103	0
[Pebbly Gravel, 34 feet].	Coarse loamy sand, with quartzite pebbles	34	7	137	7
	Earthy gravel, with flint, quartzite, &c.				
	Clean gravel, with flint, quartzite, and vein-quartz				
[Norwich Crag, 61 feet.]	Shelly gravel. *Mya*, *Tellina*, *Cardium edule*, *Mytilus*, *Pecten*, *Balanus*	5	0	—	
	Gravelly sand	(?)22	0	—	
	Shell-bed (sand ?) *Mya arenaria*, *Mytilus*, *Cardium*, *Purpura lapillus*, *Cyprina islandica*, *Mactra*, *Balanus crenatus* ...	1	5	—	
	Greenish sand, with shells ...	28	0	—	
	Green micaceous sandy silt ...	4	0	198	0
[Upper Chalk]	Chalk with flints	112	0	310	0

An account sent by MESSRS. ISLER differs somewhat in details and makes the water-level only 69 feet down. It is thought better to give the above, which was carefully noted from specimens.

Other accounts vary in details; but the above is chiefly from the specimens, described by C. REID.

New Buckenham, *see* Buckenham.

Northrepps.

Ordnance Map 131, new ser. (Norfolk 11, S.E. and 19 N.E.). Geologic Map 68, E.

1. Bull's Row.

Local Government Board Ret. 1915, p. 293.

J. H. Gurney supplies part of the parish from this well. Average daily quantity of water available 4,000 gallons. Daily average supply 1,000. Quality good.

2. The Hall, just south of the main building, from TILLEY. 1899.

Water-level 110 feet [down ?]

		Thickness. Feet.
[Glacial Drift, and ? Crag, 250 feet.]	Sand with layers of gravel and boulders ...	16
	Sand and stone with gravel and boulders ...	85
	Marl	4
	Live sand	16
	Brick earth	1

Northrepps—*continued.*

		Thickness. Feet.
[Glacial Drift, and ? Crag, 250 feet.] —*cont.*	Live sand	29
	Marl	4
	Live sand	51
	Clay	1
	Live sand	11
	Whitish clay	1½
	Live sand, to chalk	30½

According to the Report of the Medical Officer of the Erpingham Rural District (1903), "The three wells in Northrepps (used for public supply) have all been shewn to be polluted."

North Tuddenham, *see* Tuddenham.

North Walsham, *see* Walsham.

Norton, *see* Blo' Norton and Wood Norton.

Norwich.

Ordnance Map 161, new ser. (Norfolk 63). Geologic Map 66, N.E.

1. Anchor Brewery. Messrs. Bullards.

Well 35 to 40 feet deep, in Chalk.—H. B. Woodward.

The following from a later note (1906). About 100 feet deep. Pump about five hours a day. Maximum yield 15,000 gallons a day. Water with high nitrates.

2. Ber Street, by the church.

From — Gidney.

To Chalk 80 feet, including 10 feet of brick-earth.

3. Caley's Mineral Water Works. 1890.

Made and communicated by Messrs. Le Grand and Sutcliff.

Tubed for 150 feet.

Water-level 88 feet down.

Originally 307 feet deep (? yield 12 gallons a minute). The supply doubled by deepening. A later note (1905) says 500 gallons an hour, the water being good, and that pumping, from the 4-inch bore, can only be done for a limited time : this perhaps is because of the newer boring.

Old well (the rest bored)	101	412 feet.
[Upper] Chalk and flints	311	

A second well (80 yards off) is said to pass through 30 feet of sand, and then Chalk to 500 feet. The rest-level of the water was 96 feet down and the yield 5,600 gallons an hour ; but the quality was bad and the water was unfit for drinking : it may have come from surface-beds.

For an analysis of the water *see* p. 160.

4. Carrow Works. Messrs. Colmans. Within a few yards of the River Wensum.

Deep Boring, of 1862 ?

Various accounts of this well have been published, with slightly conflicting figures. In view of its importance it is perhaps best to give these accounts, in chronologic order.

The first seems to be that by C. B. Rose, in *Proc. Geol. Assoc.*, vol. i, No. 8, p. 229 (1862) with the following section :—

		Thickness. Feet.	Depth. Feet.
Alluvium		16	—
Chalk, 1,152 feet	Chalk with flints	1,050	1,066
	Chalk without flints	102	1,168
Upper Greensand		6 to 8 (say 7)	1,175
Gault		22	1,197

Norwich—*continued.*

The Rev. J. Crompton, in the same year described the boring, in more detail, at the meeting of the British Association, and his paper was published (? in full) in *The Geologist*, vol. v., pp. 460–462 (1862), and in a shorter form in *Rep. Brit. Assoc.* for 1862, sections, p. 70 (1863). His version of the section is as below, and incidentally we find that this record is of a second attempt, for he says "The first well failed in consequence of the iron tubing employed to case the bore slipping across and completely obstructing the action of the machine, at a depth of 775 feet. The second is being sunk a few yards off, on the same level."

The whole boring was full of water to within 16 feet of the surface.

The greatest obstacle was met with in the Gault, from the softness of the material and an accident led to the work being stopped.

		Thickness. Feet.	Depth. Feet.
Alluvium		12	—
Chalk, 1,135 feet	Hard chalk, with flints at distances of about 6 or 7 feet	483	495
	Soft chalk	10	—
	Hard chalk, with flints as before ...	190	695
	Hard chalk, with flints about 4 feet apart	350	1,045
	Chalk without flints	102	1,147
Upper Greensand		6	1,153
Gault, with characteristic fossils, not yet passed through		36	1,189

This section is repeated by H. B. Woodward, in the Norwich Memoir; but (apparently through an error in reading Crompton's account) 17 feet is added to the first mass of Chalk, making it 500 feet thick (whereas it is spoken of as going to the depth of 500 feet), the Chalk being therefore made 1,152 feet thick, and the total depth 1,206. The figures in *The Geologist* are added up wrongly.

In 1864 W. Mather gave the following account:—

Chalk, with layers of large flints, about 6 feet apart, about 700 feet.
Harder chalk, with beds of flints about 3 feet apart, about 400 feet.
Blue marl and Galt clay, 84 feet.

He adds the following interesting particulars of the work:—

"The presence of so many flints seriously impeded the progress of the boring, by falling into the hole and jamming the tool. The first 900 ft. of this hole was accomplished in 130 days, including all stoppages . . . . giving an average of 7 ft. per day."

"For a period of one month during this time the rate of boring was 16 ft. per day . . . The average progress of boring through the whole depth, exclusive of stoppages to 120 days, 2 ft. 3 in. per day; and including all delays . . . . 1 ft. 9 in. per day."

"The hole was not tubed at all, so that neither rope nor boring-head had any protection."

The following account is given by Woodward (in the Norwich Memoir) as from a MS. Section-book in the Geological Survey Office.

	Thickness. Feet.	Depth. Feet.
Alluvium	12	—
Chalk	1,030	1,042
Upper Greensand	16	1,058
Gault	36	1,094
Lower Greensand (water).		

But the last entry is doubtful, and the section not so trustworthy as Crompton's.

In 1883 I was enabled to add some particulars to the foregoing accounts, from specimens and a drawing (dated 16 June, 1862) shown to me at the works. (*Proc. Norwich Geol. Soc.*, 1884, pt. viii, pp. 250, 251).

The boring is of 22 inches diameter; but the lower part less (? 18 inches). Instead of being a failure, as had been thought, nearly all the water-supply then came from it. The failure was only in not reaching Lower Greensand.

The water rose to the level of the river and was never lowered more than 10 feet by pumping.

Of the specimens there are many down to 580 feet; but these show nothing but ordinary white chalk and flints. Below that there is a gap in marked specimens.

Four specimens from 1,090 feet are of hard chalk, rather cream-coloured, and nodular. Three specimens from 1,095 feet are of the same kind. All these are like the hard Lower Chalk of West Norfolk.

Norwich—*continued.*

There were two unmarked specimens of grey Chalk Marl, and a specimen of Chalk Marl full of glauconitic grains and with a piece of a phosphatic nodule, clearly from the base of the Chalk.

A note in the office speaks of "No 2 Artesian Well, 1859."

The drawing gives the following section :—

To the bottom of the Chalk (details needless)	1,152	1,196 feet.
Marl and green sand [? base-bed of Chalk Marl]	6	
Apparently Gault, but perhaps partly Upper Greensand ...	38	

Later well (1898).

Sunk and communicated by MESSRS. ISLER AND CO.

Lined with 40 feet of 20-inch tubes, 10 feet down ; 44 feet of 18-inch tubes, 9 feet 10 inches down ; 60 feet of 15-inch tubes, 8½ feet down.

Water-level in pit about 2 feet down (in well ?), 9 feet 4 inches. Supply 24,000 gallons an hour. A later account says 10,860.

Dug well (the rest bored)		12	379 feet.
[Upper Chalk]	Chalk	6	
	Chalk and flints	44	
	Chalk	317	

The yield from the two wells is said to be 6 million gallons a week. The water from both is practically the same in character, good, but very hard. For analysis *see* p. 160.

5. Gurney's Bank.

S. W. UTTING told me that the ground beneath was found, during alterations, to be honey-combed with wells, some apparently only 10 or 12 feet deep.

6. Messrs. Hills and Underwood's Distillery. Boring, 1874.

Recorded by REV. J. GUNN (Norwich Geol. Soc., 6th April, 1875).

Made earth	3	270 feet.
Sand	2	
Silt with shingle and river-mud, at 2 feet from the base of which a human skull was said to have been found	37	
Chalk	228	

A later note (1906) gives the following particulars :—

The original depth was 307 feet, with a 10-inch tube to 150 feet.

Yield 10,000 to 11,000 gallons, with three hours pumping, when it ceased. Water ran to the river-level during the night.

The boring was deepened to 507 feet, and then to 607 ; but with no improvement in the yield.

Typical Chalk-water.

7. Kett's Castle Villa.

Well, 160 feet, into Chalk.—H. B. WOODWARD.

8. Messrs. Morgan's Brewery.

Section by T. CLARK.

Sunk about 35 feet, the rest bored. Water-level 29 feet down.

Made earth	about 12	230 feet.
Chalk with flints	„ 218	

Another account makes the figures 8 and 222.

A later note (1906) gives the following details :—Depth 232 feet (two wells). Water stands at the river-level. Pump about five hours (20,000 gallons a day) Water very hard, with high nitrates.

9. Mousehold, by Brickyard near centre of Common.

Well, 110 feet, into Chalk.

Norwich—*continued.*

10. Mousehold, Mr. John Harvey's.

Communicated by Mr. Lawrence.

Sand and gravel	60	160 feet.
Chalk	100	

11. Farm upon Mousehold.

R. C. Taylor, Geology of East Norfolk, p. 17.

Diluvial gravel and sand	88	132 feet.
Conglomerated crag shells...	2	
Chalk	42	

12. Mousehold Heath. New Barracks. 1895, or before.

Made and communicated by Messrs. Gidney.

	Thickness. Feet.	Depth. Feet.
Made soil	6	—
Large stones	25	—
Sands and gravel	76½	107½
Chalk	131	238½

A note of 1906 says that this well furnishes only half the requirement, the remainder being taken from the Water Company.

13. Mousehold Heath. New Prison. 1895, or before.

Made and communicated by Messrs. Gidney.

	Thickness. Feet.	Depth. Feet.
Made soil	5	—
Large stones	12	—
Sands and gravel	76	93
Chalk with flints	73	166

14. A note of 1906 says that a well at Mousehold Heath, to a depth o 250 feet below Ordnance Datum, yielded 800 gallons an hour of fair water, used for drinking.

15. Pockthorpe Brewery. Messrs. Steward, Patteson, Finch, and Co.

Communicated by A. Ferraby.

"Supply unlimited."

Alluvium	20	250 feet.
Chalk	230	

A later note (1906) makes the depth to the Chalk 30 feet, and the total depth 336. Rest-level of water 24 feet down. Yield 14,000 gallons an hour. Water has become polluted; with high nitrates and nitrites. For an analysis *see* p. 161.

16. Thorpe Hamlet, Rosary Cemetery.

From H. B. Woodward's Notes.

Brick-earth	50	100 feet.
Sand and gravel		
Chalk	50	

17. Messrs. Young, Crawshay, and Youngs' Brewery.

Well about 300 feet in depth. Water found at all depths. Level about 10 feet beneath surface. Does not sink above 3 or 4 inches when they are pumping, and afterwards regains its ordinary level in a few minutes.—H. B. Woodward.

According to Messrs. S. F. Baker and Son, the depth to the Chalk is 65 feet.

A later note (1906) gives the following particulars:—Depth only 200 feet, with a 12-inch tube 100 feet into the Chalk; rest-level 12 feet down (river-level); yield 12,000 gallons an hour; but the water not safe for use.

Norwich—*continued.*

18. Allen's Nursery.

To 30 feet below Ordnance Datum. No yield (? 150 feet).

19. Crape Works. St. Mary's Mills. F. Hinde and Son.

500 feet deep. No yield.

20. Workhouse.

(Note of 1906.) Two wells, connected, 8½ and 12 feet diameter, 120 feet deep, with a 6-inch boring, 54 feet deep, in the larger well.

Yield 23,000 gallons a day, but diminishing appreciably, supposed to be because of a deeper well being made in the neighbourhood. Quality of the water fair. For an analysis *see* p. 161.

According to a note of H. B. Woodward, a well in Norwich Castle, sunk into Chalk to a depth of 115 feet, holds water.

Ormesby St. Margaret's.

Ordnance Map 148, new ser. (Norfolk 54, S.W. ? and S.E.). Geologic Map 67, N.

In the angle of the road, ⅝ mile E. of the Church.

Water rose to within 6 feet of the surface, and has remained at about that level; but once it rose to the surface.

Sand	6	40 feet.
Boulder Clay	34	

Old Buckenham, *see* Buckenham.

Pentney.

Ordnance Map 160, new ser. (Norfolk 46, S.W.) Geologic Map 65.

Site not given. C. B. Rose, Phil. Mag., ser. 3, vol. vii., p. 180.

Soil		4	17½ feet.
[Gault, chiefly]	Rubble chalk, succeeded by stiff blue clay, with *Belemnites minimus*	10	
	Hard grey limestone, with *Terebratula biplicata*	½	
	Very tenacious blue clay	2	
[Lower Greensand]	Black sand	1	

Plumstead, Great.

Ordnance Map 162, new ser. (Norfolk 64, N.W. or S.W.) Geologic Map 66, N.E.

Farm nearly opposite the old racecourse at Plumstead.

Mentioned by J. E. Taylor at the meeting of Norwich Geol. Soc., Nov. 7, 1871 (*Norfolk News*).

Beds of shells at the depth of 80 feet.

Plumstead Hall.

Communicated by W. L. Sutton.

A 6-inch boring 231 feet deep, with water 20 feet down, yielding 2,000 gallons an hour.

Plumstead, Little.

Ordnance Map 162. (Norfolk 64, N.W.) Geologic Map 66, N.E.

By road between the village (Plumstead Street of old map) and Norwich, on the eastern side of the East Norfolk Railway.

Brick-earth about 30 feet, sandy at top. H. B. Woodward.

Poringland.

Ordnance Map 161, new ser. (Norfolk 75, S.E., 76, S.W.) Geologic Map 66, S.E.

I was told by J. T. Todd that a Mastodon's tooth was found at the bottom of a well. The specimen is preserved in Gurney's Bank. H. B. Woodward.

Pulham St. Mary.

Ordnance Map 175, new ser. (Norfolk 106, N.E.) Geologic Map 50, N.E.

Two wells, sunk and communicated by W. LIMMER [? which of the two villages.]

1. The Hall.

Water rose 4 feet.

[Glacial Drift]	[Boulder] Clay	30	50 feet.
	Loam and sand	20	

2. By Station.

Water rose 55 feet.

Boulder Clay, to sand and water, 60 feet.

3. Malt Kilns, F. Rutter & Co.

Bored (6-inches diameter) and communicated by MESSRS. F. SMITH & SON.

Clay	72	147 feet.
Chalk	75	

Water-level 28 feet down. Yield about 3,000 gallons an hour. Water of good quality.

Redenham, *see* Wortwell.

Reedham.

Ordnance Map 162, new ser. (Norfolk 77, S.) Geologic Map 66, S.E.

Reporting in 1913 the Medical Officer speaks of the supply for a group of cottages on the marsh at Berney Arms. The only available supply was from rain-water, which was insufficient in dry seasons, when it was supplemented by water taken from the river. Some years before a tube-well was sunk, but its water was so impregnated with iron as to be of no use.

Rockland All Saints.

Ordnance Map 161, new ser. (Norfolk 85, N.W. or S.W.) Geologic Map 66, S.W.

1. Kirk Hall Farm. 1894?

Made and communicated by MESSRS. GIDNEY.

Well 18 feet, the rest bored.

Rest-level of water 50 feet down. Rose at first to 3 feet above ground, but fell later.

		Thickness. Feet.	Depth. Feet.
Made soil...		1½	—
[Boulder Clay]	Light-coloured clay	8	—
	Blue clay	98	107½
[Upper]	Chalk and flints	25	132½

2. Magpie Inn (? All Saints or St. Peter's).

Sunk and communicated by — POOLEY, of Besthorpe.

[Boulder] Clay, to sand and water, 22 feet.

Rollesby.

Ordnance Map 148, new ser. (Norfolk 53, S.E.). Geologic Map 67, N.

Clay-pit, ¼ mile W.N.W. of the church.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift.]	Boulder Clay	18	—
	Hard conglomerate	⅓	—
	Red gravel	3	—
	White sand	3	—
	Loam	5	—
	Stony brown loam	15	44⅓
[Pebbly Series.]	Gravelly sand, with water ...	5	49⅓

Roudham.

Ordnance Map 174, new ser. (Norfolk 94, S.E.). Geologic Map 66, S.W.

Harling Road Aerodrome. 360 yards south of Harling Road Station, 1916.

Communicated by the War Office.

80 feet above Ordnance Datum.

? Sunk 10 feet. Then a boring of 4 inches diameter.

Rest-level of water, 64 feet down.

Yield found by pumping to 12 hours, 6,600 gallons. Pumping has gone on practically every day since the bore was finished, 14 September, 1916, to date (27th November).

Sandy soil		2	
[Chalk.]	Marl	2½	70 feet.
	Soft creamy chalk	14½	
	White chalk, fairly hard	41	
	Hard flint	1½	
	Water-vein	1¼	
	Flinty chalk	7¼	

Rougham.

Ordnance Map 146, new ser. (Norfolk 35, S.E. and S.W.). Geologic Map 65.

Piper Wood.

Sunk and communicated by J. Seaman, of Great Massingham.

Drift.	Sand	about 20	about 100 feet.
	Clay	„ 30	
	Sharp sand	„ 50	

Roughton.

Ordnance Map 131, new ser. (Norfolk 19, N.E.). Geologic Map 68, E.

Roughton Heath. For the Cromer Isolation Hospital, 1900.

Made and communicated by F. Bennett, of Ipswich.

Well 12 feet (dry), the rest bored. Top of tube 9 feet from the surface, bottom 8½ feet in the Chalk, or 204 feet from the surface.

Test, by hand-pumps, showed a yield of 1,000 gallons in 1½ hours.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift.]	Red sand mixed with small stones	28½	—
	Dark red sand and stones ...	½	—
	Fine light-coloured sand	31	—
	Gravel and small stones	5	—
	Red sand free from stones ...	4	—
	Rough red gravel	3½	—
	Bright red sand	3½	76
	White-coloured sand	31	—
	Clay	1	—
	Dark sandy loam	22	—
	Light-coloured running sand ...	39	—
	Dark clay	4	173
[? Pliocene.]	Light-coloured running sand ...	7	—
	Dark sandy loam	1	—
	Rough sand	11½	—
	Light-coloured loam	½	—
	Dark loam and gravel	1½	—
	Flint bed	1½	196
[Upper.] Chalk and flints		106½	302½

Roughton—*continued.*

Roughton Heath Isolation Hospital of the Erpingham Rural District Council. 1913.

About 210 feet above Ordnance Datum.

A small well, about 4½ feet, then a four-inch bore.

Bored and communicated by Messrs. Le Grand and Sutcliff.

Rest-level of water, 89 feet down.

Yield 540 gallons an hour, with suction-pipe only 5 feet in the water and no noticeable effect on the water-level when pumping all day.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift.]	Fine gravel	9	—
	Light-coloured sand, large stones and gravel	28	—
	Sea-sand	15	—
	Gravel	7½	59½
	Brown clay	2½	—
	Chalk [? boulder]	11	—
	Light-coloured hard sand. Water at 87 feet	26	99
	Light-coloured blowing sand	27	—
	Black sandy clay and small stones ...	14	—
	Loamy sand	41	—
	Clay and chalk stones	13	—
	Sand and chalk (or black ?) pebbles ...	7	201
[? Crag.]	Light-grey blowing sand	13	—
	Black flints and pebbles	1	215
[Upper Chalk.]	Chalk and flints, rubbly	23	—
	Soft chalk and flints	59	—
	Very hard chalk and flints	8	—
	Chalk and flints	13	318

The Medical Officer of the Erpingham Rural District says (1913) of this straggling village: "The water supply is from shallow wells; recently there has been a shortage of water owing to the collapse of one of the wells."

Roydon.

Ordnance Map 175, new ser. (Norfolk 105, S.W., and 110 N.W.). Geologic Map 50, N.W.

Two wells, made and communicated by W. Limmer.

1. The Hall. Water rose 5 feet.
   [Boulder] Clay to sand, 50 feet.

2. The Rectory.

[Glacial Drift.]	[Boulder] Clay	30	50 feet.
	Sand	20	

Rudham, East.

Ordnance Map 146, new ser. (Norfolk 24, station in S.E.). Geologic Map 69.

Information obtained by H. B. Woodward.

1. Railway Station. Boulder-clay and chalk 34 feet.
2. Inn by the Station. „ „ 29 „

The water stands about 4 feet deep.

Rushall.

Ordnance Map 175, new ser. (Norfolk 106, S.W.). Geologic Map 50, N.E.

Two wells sunk and communicated by W. Limmer.

1. ? Locality. 2. Half Moon Inn.

		1.	2.
[Glacial Drift]	[Boulder] Clay	30	33
	Sand	Touched (water).	15

Rushall—*continued.*

3. For military purposes. Almost half-a-mile northward of the church and just south of the parish-boundary (with Pulham).

Communicated (with specimens) by the Metropolitan Water Board. (J. W. Restler).

129·1 feet above Ordnance Datum.

Sump of 8 feet internal diameter, 28½ feet; 16 inches borehole, lined from 28 to 113 feet down, unlined below.

Rate of yield 17,500 gallons an hour; depth to water-level after continuous pumping 33 feet down. Rate of yield 25,000 gallons an hour got for a short time, lowering the water-level to 39½ feet down. Rate of yield 21,000 gallons an hour maintained for some hours, with water-level 35 feet down.

		Thickness. Feet.	Depth. Feet.
Soil (brown, loamy)		¾	—
[Glacial Drift, Boulder Clay to 26¼ feet.]	Brown clay (with some small bits of flint, partly sandy; decalcified boulder clay)	3½	—
	Light-coloured marly clay (grey and brown; small pebbles of chalk; a boulder clay)	2	—
	Stiff brown loam	5½	—
	Blue marly clay (grey, chalky, partly streaky; a boulder clay)	14½	26¼
	Stony gravel (stones and sand) ...	7½	—
	Loamy sand (brown, some flint) ...	2½	—
	Coarse red sand (brown, some flint) ...	5¼	—
	Stiff dark loam (brown sandy clay; some flint)	1½	—
	Sharp sand (brown, bits of flint) ...	1¼	—
	Sharp beach-sand, fine at top, gradually getting coarse (brown, with flints, some of fair size)	46½	—
	Sandstone	¾	—
	Very coarse sharp sand and small stones (brown, with flints)	3¾	—
	Flint bed (with some flint pebbles and a few pebbles of quartzite)	2	97¼
[Upper]	Chalk and flints (white chalk, lowest specimen flints)...	196¾	294

For an analysis of the water, *see* p. 162.

Rushford.

Ordnance Map, 174, new ser. (Norfolk 103, S.W.). Geologic Map 50, N.W.

Snarehill Aerodrome. At the southern edge of Great Snarehill Belt, west of Seven Hills Plantation. 1915.

Communicated by the War Office.

140 feet above Ordnance Datum.

A boring of 8 inches diameter. Rest-level of water 49 feet down.

Supply for 19 (? 9) hours, 4,500 gallons an hour. Level of water at cessation of pumping unchanged. Pumping, of varying amount, has gone on practically each day since the bore was finished, 15th July, 1916, to date (27th November).

		Thickness. Feet.
Sandy and vegetable soil		1½
[Chalk] 232½ feet.	Marl and chalk	4
	Flinty chalk	86
	Hard petrified crust	2
	Water-vein	20
	Flinty chalk	6
	Water-vein	3½
	Flinty chalk	26
	Water-vein	5
	Flinty chalk	49
	Hard petrified crust	2
	Water-vein	29

Rvburgh, Great.

Ordnance Map 146, new ser. (Norfolk 25, S.E.). Geologic Map 68, S.W.

Just south of railway station.
Chalky Boulder Clay, to 20 feet.

Saham Toney.

Ordnance Map 160, new ser. (Norfolk 72, S.W.). Geologic Maps 66, S.W. & N.W.

1. Broomley Hall (should be Broom Hill), southward of the Mere. 1898 ?

Boring, made by MESSRS. ADCOCK. Communicated by F. W. HARMER.

		Thickness. Feet.	Depth. Feet.
Glacial Gravel		20	20
Boulder Clay	Blue clay	80	100
	Hard flints with clay	10	110
	Chalk and chalk marl	2	112
	Clay	35	147
Chalk.			

2. Park Farm. About 2 miles N. of the village.
Sunk and communicated by MR. THUXTON.
Boulder Clay (not bottomed), 60 feet.

3, 4. Saham Hall.

Two Borings. Made and communicated by J. E. NOBLE.
(Summary of Progress for 1910, p. 75.) 1911.

No. 1. In yard, a little N.W. of the house. About 150 feet above sea-level.

		Thickness. Feet.	Depth. Feet.
Soil		1½	—
[Glacial Drift]	Ballast [gravel]	6	—
	Gravel and sand	10½	—
	Grey sand	14	—
	Clay	2½	—
	Chalk and clay (Boulder Clay) ...	126½	161
	Grey sand (with pellets of chalk) ...	11	—
	Clay and chalk	36⅓	—
	Chalk (Boulder Clay)	39⅔	248

No water. Boring abandoned.

No. 2. 200 yards W.N.W. of No. 1. 1911. About 145 feet above Ordnance Datum.

Water rose to within 12 feet of the surface. Yield 1,000 gallons an hour. Analysis good. Hardness 23°.

Soil		1½	261 feet.
[Glacial Drift]	Ballast [gravel]	2½	
	Clay and sand	13	
Chalk and flints		244	

Borings 1 to 3 show a deep hollow of Drift, previously unsuspected, further evidence of which is given by another boring, near by, at Broomhill, in the parish of Merton (given as Walton in the Summary). *See* p. 102.

5. MR. NOBLE states that a well was dug to a depth of 42 feet, 500 yards N.E. of Saham Hall, and is said to have yielded a fair supply from the Chalk ; but too much reliance must not be placed on the distinction of Chalk from chalky Boulder Clay by workmen (Summary, p. 76).

St. Faith's Rural District.

The Medical Officer reported (1912 and 1913) that whilst Catton and Sprowston got a supply from the Norwich Water Co., most of the parishes depended on surface-wells. In wet seasons the water in many of these (as in St. Faith's, Horstead and Haynsford) is only a foot or a little more below the ground.

Concerning Lenwade *see* p. 50.

Sandringham.

Ordnance Map 145, new ser. (Norfolk 23, N.W.). Geologic Map 69.
For the estate. But perhaps not in the parish. ? West Newton.

1. Trial bore, 1885, made and communicated by MESSRS. T. TILLEY & SON. Plenty of good, but rather hard, water. About 184 feet above Ordnance Datum.

		Thickness. Ft.	In.	Depth. Ft.	In.
Made ground		7	0	—	
Lower Greensand — Upper Division—Sand		6	6	13	6
Middle Division — Coloured Clay ...		2	0	—	
Blue Clay... ...		12	0	27	6
Lower Division — Black sand, hard...		8	6	—	
White sand, hard		12	0	—	
Grey sand... ...		14	6	—	
Hard rock ...		0	4	—	
Grey sand to rock		7	0	69	10

2. A newer well, about 30 feet from the above boring, from centre to centre 1915.

From a drawing amongst the papers of the late C. E. HAWKINS.

Brick shaft, of eight feet diameter; then cylinders of the same size, to over 14 feet; then a smaller brick shaft, to 26 feet down; then tubes (?) to 44 feet. The rest bored, 12 inches diameter to 72 feet down, tubed to 65 feet, then open. The last 8 feet, a 4-inch bore.

Water-level 47·5 feet above Ordnance Datum.

			Thickness. Feet.	Depth. Feet.
[Made ground]		Loose earth	7	—
[Lower Greensand]	[Upper Division]	Sand with a layer of carstone at top and just above the middle ...	7	14
	[Middle Division]	Coloured clay, with chalky pyrites at top, shale below the middle, limestone at the bottom ...	5	—
		Blue clay, with lignite near the middle and at bottom	7	26
	[Lower Division]	Hard black sand, with shale at bottom	10?	—
		Sand, with shale at bottom ...	2	—
		Hard white sand	10?	—
		Grey sand, with hard sandstone at the bottom	14½	—
		Loose gravelly bed	2	—
		Very hard sandstone	½	—
		Gritty beds and shale	7	72
[Kimeridge]		Sandy clay to black clay	8	80

3. An account of a boring (at a different site) made in 1872, given by J. MANSERGH (to PROF. T. R. JONES, who supplied notes in brackets from specimens), differs considerably, being as follows:—

118½ feet above Ordnance Datum.

			Thickness. Feet.	Depth. Feet.
Red Chalk			6	6
Lower Greensand	Upper Division	Carstone	14	—
		Greensand (brownish-green sand)	10	—
		Stone, with mineral	1½	—
		Greensand (greenish-brown sand, with nodules of pyrites at top, then sand stained green) ...	15½	47
	Middle Division	Stiff blue clay (sandy clay) ...	5	52
	? Lower Division	Blue stone (light brown clayey sand)	16	68
		(Black clayey sand) / (Light grey very sandy clay) — thickness not given	—	100

Boring left off at the depth of 100 feet, without reaching Kimeridge Clay.

Scole.

Ordnance Map 175, new ser. (Norfolk 110, N.E.) Geologic Map 50, N.W.

Dr. Curteis'.

Sunk and communicated by W. LIMMER.

[Glacial Drift]	[Boulder] Clay	20	40 feet.
	Gravel and sand	20	

Scottow.

Ordnance Map 147, new ser. (Norfolk 40, N.W.). Geologic Map 66, N.E.

Communicated by W. L. SUTTON.

Well of 3½ feet diameter.
From top of well to water, 38 feet 7 inches. Water 4 feet 9 inches.
Pumped at the rate of about 10 gallons a minute.
Samples taken out behind brickwork.

[Drift]	Clay	43 feet 4 inches.
	Sand	
	Clay	
	Black clay, 9 feet	
	Silver sand ...	
	Sand, 4 feet ...	

Shaft about 10 yards away :--Sand, 6 or 7 feet. Firm clay, 8 or 9 feet

Sculthorpe.

Ordnance Map 146, new ser. (Norfolk 16, S.W.). Geologic Map 68, S.W.

Cranmer Hall.

[Glacial Drift.]	Gravel and sand	22	22 feet.
	Chalk		

Shelfhanger.

Ordnance Map 175, new ser. (Norfolk 105, N.W. and S.W.). Geologic Map 50, N.W.

Four wells, sunk and communicated by J. BANHAM.

1. Mr. Annis'. Sunk 45 feet, bored 25. Water rose 25 feet.
2. Mr. Ellis'. Water rose 10 feet.
3. The Green. Water overflowed.

	1.	2.	3.
[Boulder] Clay to sand...	70	21	20 feet.

4. Hill Cottages. Boulder Clay 40 feet.

Sheringham.

Ordnance Map 131, new ser. (Norfolk 10, N.E., and 11, N.W.). Geologic Map 68, E.

Sheringham Water Co.

Local Government Board Return of 1915, p. 212, and other information.

Springs. Average daily quantity available 96,000 gallons. The water is collected in open channels, and filtered through gravel to take out coarse sediment.

Wells in Chalk. Sheringham and Beeston Commons.

Average daily supply 100,000 gallons, but 120,000 more could be got. The level of the well-water varies little, however much pumping takes place.

Average daily supply 130,000 gallons (from both sources ?).

Water is filtered. Quality satisfactory. 1914. Hardness 14°, permanent 5·5°.

Supplies Sheringham Urban District and Beeston Regis.

The Water Works Directory of 1911, p. 324, says that the population supplied was about 3,500, and that the water of the springs from Sheringham Woods was soft and of excellent analysis.

Sheringham—*continued.*

Waterworks Well.

152 feet above Ordnance Datum.

Communicated by R. M. PARKINSON.

A 10-inch boring. From 14th March to 5th May, 1899. pumping 7,000 gallons an hour for 10 hours a day had no effect on the water-level (? words in brackets from specimens).

		Thickness. Feet.	Depth. Feet.
[Contorted Drift.]	Gravel	3	—
	Clay, with small stones...	20	—
	Loamy sand (grey sandy loam, with small stones. Boulder Clay?) ...	9	—
	Running sand (ferruginous)	35	—
	Boulder Clay (with chalk)	2	—
	Running sand (ferruginous)	21	96
	Running sand, bluish	15	—
	Boulder Clay, with flints (chalk, etc.)	2	107
[Forest Bed.]	Sand and small flints (earthy, *Cyprina islandica*, *Tellina balthica*, *Mytilus edulis*, *Litorina litorea*)	6	—
	Clay, with chalk and flints (marine shells)	17	—
	Flints and chalk mixture (? derived from above)	7	—
	Blue clay (grey earth and micaceous sandy loam, with small stones) ...	2	139
[Upper]	Chalk, soft	261	400

Shimpling.

Ordnance Map 175, new ser. (Norfolk 105, S.E.). Geologic Map 50, N.W.

1. The Green.

Sunk and communicated by J. BANHAM.

Water rose 30 feet.

[Boulder] Clay 35 feet.

2–4. Sunk and communicated by W. LIMMER.

2. The Hall. 3. The Place. 4. The Rectory. "Red Iron Spring" water overflowed.

[Boulder] Clay 40, 50, and 20 feet.

Shotesham All Saints.

Ordnance Map 161, new ser. (Norfolk 87, N.E.). Geologic Map 66.

Upgates Farm. 1906.

Made and communicated by MESSRS. FAKE, of Norwich.

		Thickness. Feet.	Depth. Feet.
Well [old?]	... ...	—	70
[Glacial Drift.]	Loam and sand	3½	—
	Yellow sand, fine	8	81½
[? Crag.]	Rough red sand	6	—
	Slate-coloured sand and stones. Smells bad	10	—
	Blue sand...	13½	—
	Stones	1	112
[Chalk.]	Marl	4	—
	Chalk	21	—
	Sand-gall...	4	—
	Chalk	55	196

Smallburgh Rural District.

The Medical Officer reports (1912) that "all the water for drinking and domestic purposes is obtained from wells, which number no less than 144. Many houses have their own well, in other cases 2, 3, or 4 houses obtain their supply from a common well."

He says "there is grave and increasing risk of contamination of the wells and an ever-present risk of an outbreak of some water-borne disease," and he notices carelessness and untidiness.

On analysis of their water, by MR. SUTTON, several wells were condemned.

Snettisham.

Ordnance Maps 129, 145, new ser. (Norfolk 14, N.W and S.W.). Geologic Map 69.

Information from — CHILVERS (who made the wells).

1. Cottages by brickyard ; well about 20 feet deep in sand.

2. At Grammar School, on rising ground north-east of the Hall ; well about 50 feet deep, with 4 feet of water. The top 6 feet black earth or silt [clayey beds of the Lower Greensand], the rest sand.

Snoring, Great.

Ordnance Map 130, new ser. (Norfolk 16, S.W.). Geologic Map 68, S.W.

North-east of Thorpland Plantation.

Communicated by the REV. J. LEE-WARNER.

Boulder Clay, to sand, 28 feet.

South Burlingham, *see* Burlingham.

Southwood.

Ordnance Map 162, new ser. (Norfolk 77, N.W.). Geologic Map 66, S.E.

The Oaks Farm, about ¼ mile S.E. of the church. 1913.

Made and communicated by MESSRS. FAKE, of Norwich.

Water rose to 50 feet from the surface.

		Thickness. Feet.	Depth. Feet.
Old well		—	43
[?Glacial Drift.]	Red sand	16	—
	Red brick-earth	6	—
	Red sand...	16	—
	Dark red clay	2	—
	Sand	5	—
	Blue clay	61	—
	Cocoa-coloured clay	38	—
	Blue clay, with layers of hard dark stone	46	—
	Hard solid dark stone	7	—
	Clay, with marl-stone	10	250
[Upper Chalk.]	Marl	28	—
	Chalk, with layers of stone	22	300

PROF. P. G. H. BOSWELL classifies the beds from 43 to 88 feet as Crag? those from 88 to 240 as London Clay, and includes the clay with marl-stone with the Chalk.

Spixworth.

Ordnance Map 147, new ser. (Norfolk 51, S.E.). Geologic Map 66, N.E.

Red brick cottage at northern end of village (S.W. of Spixworth on old Map).

From H. B. WOODWARD'S notes.

Pebbly gravel ...	27 feet.
Chalk	

Spooner Row, *see* Wymondham.

Sprowston.

Ordnance Map, 161, new ser. (Norfolk 63, N.E.). Geologic Map 66, N.E.

1. Gunnell's Brickyards.

Wells sunk 70 or 80 feet into Chalk. H. B. WOODWARD.

2. For John Gurney.

Sunk and communicated by MESSRS. LE GRAND and SUTCLIFF.

Sand		28	111 feet.
Chalk, very pure water, full of small shells		83	

3. Heath Farm.

Gravel about 30 feet. H. B. WOODWARD.

Stalham.

Ordnance Map 148, new ser. (Norfolk 41, N.W.). Geologic Map 68, E.

Board School.

Recorded by C. REID.

Glacial Drift	Brick-earth	9 or 10	? 22½ feet.
?	Sand, clay, and gravel... ...	10	
? Forest Bed	Clean sand	3	

Stanhoe.

Ordnance Map 130, new ser. (Norfolk 15, N.W.). Geologic Map 69.

Information about several wells obtained by G. BARROW.

1. The village well was 170 feet deep but has been deepened by 10 feet, as it failed in summer. Now 180 feet, of which rather more than 30 feet is clay, the rest is chalk.

2. Great Barwick well, said to be a hundred feet deep or rather more. In winter and spring the water rises to within 30 or 40 feet of the surface, but in the summer it sinks at least 20 feet and sometimes more.

3. Well at cottage close to the railway station. This is 60 feet deep, 10 feet through marl and 50 feet through hard chalk. The water varies in level; in April, 1883, it was about 30 feet from the surface.

Starston.

Ordnance Map 175, new ser. (Norfolk 106, E.). Geologic Map 50, N.E.

Two wells, sunk and communicated by W. LIMMER.

1. The Green.

[Glacial Drift]	[Boulder] Clay	20	96 feet.
	Gravel and loam	76	

2. A quarter of a mile E. of the church.

[Glacial Drift]	Gravel	12	46 feet.
	Sand and loam	10	
	Sand	24	

Stibbard (? or Guist).

Ordnance Map 146, new ser. (Norfolk 26, S.W. ?). Geologic Map 68, S.W.

Sennowe Hall. 1905.

Made and communicated by W. G. FAKE, of Norwich.

Shaft 80 feet, the rest bored. Good supply.

		Thickness. Feet.	Depth. Feet.
[Drift.]	Sand and gravel	80	—
	Grey clay	3	83
[? Chalk.]	Margin marl	4	—
	Flints	1	—
	Margin marl	40	—
	Chalk	102	230

Stockton.

Ordnance Map 176, new ser. (Norfolk 99, N.W.). Geologic Map 66, S.E.

Black Boy Inn.

From C. REID'S Notes.

One account says that the well is 87 feet deep, all in sand ; another that this includes 10 feet of clay.

Stody.

Ordnance Map 131, new ser. (Norfolk 17, N.E., and S.E.). Geologic Map 68, S.W.

Stody Lodge, about two-thirds of a mile S.E. of the church. 1895.

Made and communicated by MESSRS. GIDNEY, of Norwich.

		Thickness. Feet.	Depth. Feet.
Shaft		—	68
[Glacial Drift.]	Blue clay	30	98
[? Crag.]	Dark sandy clay	9	—
	Dark sand and shells	19	—
	Red sand	6	—
	Grey sand	4	—
	Light-coloured sandy clay, with small stone	2	138
Chalk and flints	... ...	18	156

Stoke Ferry.

Ordnance Map 160, new ser. (Norfolk 70, S.W.). Geologic Map 65.

Near the Railway Station (? Dr. Baders). 1883.

Bored and communicated by T. TILLEY.

Water rose to the surface.

		Thickness. Feet.	Depth. Feet.
Sand [Drift] and water		25	25
[Lower Chalk.]	Chalk, no water	13½	—
	Yellow marl	3	41½
Gault (Blue clay)		56	97½
[Lower] Greensand, 17 feet.]	Dark green sand, no water ...	2	—
	Rock	2¼	—
	Green sand	3¾	—
	Rock	1½	—
	Sand	7½	114½

Stoke Holy Cross.

Ordnance Map 161, new ser. (Norfolk 75, S.E., 87, N.E.). Geologic Map 66, S.E.

Communicated by Miss Scott, of Bungay, to S. Woodward, MS. 1825.

Diluvial and Tertiary; at which depth a bed of Crag shells was cut through consisting of *Cardium edule*, *Murex* [= *Purpura lapillus ?*], *Trophon carinatus* [= *T. antiquus*], *Turbo* [= *Litorina*] *litorea*, *Venus æqualis* [= *Cyprina Islandica*], *Mya arenaria*, *Tellina obliqua*. Bones of deer? and vertebræ of *Plataxⁿ*...	100	270 feet.
Clay and Chalk in which no organic remains were found	170	

Stow Bardolph.

Ordnance Map 159, new ser. (Norfolk 57, S.W.). Geologic Map 65.

Stow Hall and the Home Farm.

From C. Reid's Notes.

Boulder Clay to sand (Lower Greensand), about 100 feet.

In another well, close to that at the Hall, and 114 feet deep, water was found at the depth of 27 feet.

Stratton, Long.

Ordnance Map 175, new ser. (Norfolk 97, N.W.). Geologic Map 66, S.E.

Waston House.

Boring, communicated by T. W. N. Crawford.

Gravel (Pebbles, sand, etc.)	34	56 feet.
Chalk and flints	22	

Stratton St. Michael.

Ordnance Map 175, new ser. (Norfolk 97, N.W.). Geologic Map 66, S.E.

Farm (? by high road, westward of the church).

From H. B. Woodward's Notes.

Boulder Clay, to pebbly gravel [Crag ?], 33 feet.

Swaffham.

Ordnance Map 160, new ser. (Norfolk 59, N.W., and S.W.). Geologic Map 65.

1. Swaffham Water Co. S. side of Lynn Street, about 100 yards from the Post Office. 1865.

247 feet above Ordnance Datum.

Local Government Board Return, 1915, p. 219, and other information :—

Well 165 feet, brick-lined for 20 feet down, with two headings, running north and south. The rest a bore of 14 inches diameter. All Chalk.

Rest-level of water from about 40 feet down in midsummer to 10 or 12 in midwinter. Level when pumping varies, and the well has been pumped dry.

Daily average supply 30,000 gallons, but much more could be got. Another return makes daily average 111,000 with 9,000 more in bulk.

Water excellent, hard.

According to the Water Works Directory, 1911, p. 349, the total population of the area supplied was 3,371,

Parts of the town get a supply from private wells.

2. Manor House, E. of the church.

From C. E. Hawkins' Notes, published 1893.

Well, sunk some years ago, said to have passed through 160 feet of clay.

3. Wood Farm. Half a mile S.E. of the church.

Noted by G. Barrow, Geology of S.W., Norfolk, p. 149.

The well, 130 feet deep, runs dry in summer, whilst another well, close to the railway-bridge (to N.E. ?), is never dry.

Swanington.

Ordnance Map 147, new ser. (Norfolk 50, N.E.). Geologic Map 66, N.W.

For Public Supply. About halfway between the church and the stream, on the western side of the road.

Boring made (about 1890, from the bottom of the well) and communicated by MESSRS. FAKE, of Norwich. With a note from P. NORGATE.

Tubed 80 feet. Water not fit for domestic purposes, as it contains a large amount of iron. The analysis on p. 164 hardly bears this out.

The water frequently overflowed.

		Thickness. Feet.	Depth. Feet.
[Glacial Drift]	Well (old)	—	13
	Soft grey clay	5	—
	Black bog	4	22
[Upper Chalk]	Soft chalk	50	—
	Hard chalk	25	97

The black bog may be a sandy water-logged representative of the Pebbly Gravel, of which a narrow outcrop is shown to the west, on the geologic map.

P. NORGATE writes (March, 1905) that the cottagers will not use the water, either for drinking or washing, preferring to get water from a stream close by. They say that it turns linen yellow and is not fit to drink.

Tacolneston.

Ordnance Maps 161, 175, new ser. (Norfolk 86, S.E.). Geologic Map 66, S.W.

Two wells, sunk and communicated by J. BANHAM, of Shelfhanger.

1. At Baker's, by 11th milestone. Water rose 45 feet.
2. The Hall Cottages. Water rose 80 feet.

In both, well 55 feet, the rest bored. Boulder Clay, to sand 85 feet.

Tattersett.

Ordnance Map 146, new ser. (Norfolk 24, N.E.). Geologic Map 69.

Well by brickyard north of Pinkney Hall.

Communicated by MR. MASSINGHAM.

Boulder Clay.	[Loamy top Brick-earth	5	44 feet.
	[Marl] White earth	25	
	Blue Clay with "golt" of sand that gives springs	14	

Taverham.

Ordnance Map 161, new ser. (Norfolk 50, S.E.). Geologic Map 66, N.E.

Times Paper Mill. 1868.

Alluvium		150 feet.
Chalk		

For an analysis of the water *see* p. 165.

Tharston.

Ordnance Map 175, new ser. (Norfolk 87, S.W., 97, N.W.). Geologic Map 66, S.E.

Rectory.

Sunk and communicated by GEO. BANHAM.

Water rose 6 feet.

Boulder Clay	50	56 feet.
Gravel and sand	6	

Thelveton.

Ordnance Map 175, new ser. (Norfolk 105, S.E.). Geologic Map 50, N.W

Mr. J. Manns.

Sunk and communicated by W. Limmer.

[Boulder] Clay, to sand and water, 50 feet.

Thetford.

Ordnance Map 174, new ser. (Norfolk 102, N.E. and S.E.). Geologic Maps 51, N.E., 50, N.W.

Waterworks. On the western side of the high road about two-thirds of a mile N.N.W. of the Railway Station. 1887.

165 feet above Ordnance Datum.

Communicated by J. Church and from other sources.

According to Messrs. S. F. Baker & Son, the well is 64 feet deep (rest bored) and the water-level was 2 feet in the well. Another note, of 1915, gives the rest-level of the water as 141¼ feet down, and the level when pumping as 147½.

Daily average supply 120,000 gallons (Local Government Board Return of 1915, p. 141).

Glacial Drift [Sand and gravel. Loam and clay, shown in pits close by], 50 feet (according to F. J. Bennett).

Chalk. At the depth of 155½ feet a spring of beautiful water was found, yielding a large quantity, over 14,000 gallons an hour having been pumped without reducing the head. To 160 feet.

Water excellent. Hardness, total 13·5°, permanent 2·8° (L.G.B. Return). For analysis *see* p. 165.

According to the Waterworks Directory 1911, p. 355, the population supplied is about 4,000.

Thetford St. Mary.

Although in the borough of Thetford (Norfolk) this parish seems to be in the county of Suffolk.

Internment Camp. Just S. of Warren Wood, about 1½ miles W.N.W. of Thetford.

Bored and communicated by Messrs. Duke and Ockenden.

Lined with 6-inch tubes to 80 feet down.
Water-level 20 feet down.
Tested at 1,200 gallons an hour with suction at 85 feet.

Sand and gravel		5½	
[Upper Chalk]	Marl and flints	8½	100 feet.
	Chalk and flints	86	

Thorpe Abbots.

Ordnance Map 175, new ser. (Norfolk 106, 111). Geologic Map 50, N.E.

Messrs. Kay's.

Boring. From Messrs. F. Smith and Son, of Grimsby.

Water-level 82 feet down. Supply and quality good.

To Chalk [Drift]	182	258 feet.
Chalk	76	

If all above the Chalk is Drift, a great thickness of this is proved.

Thorpe St. Andrew.

Ordnance Map 161, new ser. (Norfolk 64, S.W. and 63, S.E.).
Geologic Map 66, N.E.

1. County Lunatic Asylum. Between the railways eastward of the village.

Made and communicated by MESSRS. GIDNEY, of Norwich.

Shaft 90 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Made soil		3	—
[? Drift and Crag]	Brick-earth	9	—
	Red and grey sands	55	67
[Upper] Chalk and flints		55	122

2. Pine Banks, formerly Mr. Caley's.

A 4-inch bore, 287 feet deep. Water-level 148 feet down.

Probably 2,000 gallons a day pumped.
The water softer than ordinary Chalk-water.

Thursford.

Ordnance Maps 130, 131, 146, 147, new ser. (Norfolk 17, S.W.).
Geologic Map 68, S.W.

Between the Railway Station and the Crawfish Inn ? (in 147).

[Glacial Drift.] Sand and brickearth, 10 feet.

Thuxton.

Ordnance Map 161, new ser. (Norfolk 61, S.W.). Geologic Map 66, S.W.

High House.

Sunk and communicated by — THUXTON.

Boulder Clay, 60 feet.

Thwaite.

Ordnance Maps, 162, 176, new ser. (Norfolk 88, S.E.). Geologic Map 66, S.E.

Hall.

Communicated by D. PALMER.

Well 100 feet deep : 30 or 40 feet clay, the rest sand.

Tibenham.

Ordnance Map 175, new ser. (Norfolk 96, S.E.). Geologic Map 66, S.W.

Wells in Drift. Information got by F. J. BENNETT, from J. BANHAM, except in one case.

Wells in Boulder Clay.

1, 2. Almshouses and Long Row, Mr. Pearson's. Boulder Clay, sandy at bottom, 20 feet. Water rose 2 feet.
3. Long Row, Mr. Lester's. Boulder Clay (Land-spring), 45 feet.
4. On the Green. Boulder Clay (Land-spring), 25 feet.

Wells through Boulder Clay.

5. Boot Inn, near. Boulder Clay, to sand, 27 feet. Water rose 10 feet. From G. BANHAM.
6. Boot Inn, near. Mr. Fordham's. Boulder Clay, to sand, 78 feet. Water overflowed.
7. By the Church. Boulder Clay, to sand, 24 feet. Water rose 2 feet.
8. Greyhound Inn. Boulder Clay, to sand, 20 feet. Water rose 2 feet.
9. Long Row, Mr. Kett's. Sunk 45 feet, the rest bored. Boulder Clay, to sand, 70 feet. Water rose 60 feet.
10. Pristow Green, Mr. Self's. Sunk 50 feet, the rest bored. Boulder Clay to sand, 80 feet. Water rose 70 feet.

Tivetshall.

Ordnance Map 175, new ser. (Norfolk 105, N.E.).
Geologic Map 50, N.E. or 66, S.E.

1. Near the Church.

Sunk 50, bored 40 feet. Water rose 25 feet.
[Boulder] Clay, to sand, 90 feet.

2. At the Schools.

Sunk and communicated by W. LIMMER.
Sunk 40, bored 40 feet. Water rose 6 feet.
[Boulder] Clay, to sand, 80 feet.

Trimingham.

Ordnance Maps 131, 132, new ser. Geologic Map, 68, E.
Eastward of St. John the Baptist Church.
202 feet above Ordnance Datum.
Communicated by H. D. SEARLES-WOOD.
Sunk through rich yellow sand, 33½ feet.
Water 6 feet 4 inches deep. For analysis, *see* p. 166.

Trowse.

Ordnance Map 161 (Norfolk 63, S.E., 75, N.E.). Geologic Map 66, N.E.
Near Cooks' Cottages.
Made and communicated by — FAKE, 1885 ; and from the REV. J. GUNN.
In February, 1885, the water stood 6 feet in the well.

		Thickness. Feet.	Depth. Feet.
[Boulder Clay]	Grey clay	20	—
	Blue clay	60	80
[Crag ?]	Bright sand	25	—
	Iron pan	4	—
	Dark sand and blue clay mixed, with some substances resembling a wheat-ear in form, encrusted with a black coating (iron)	1	110

For remarks on the water, *see* p. 166.

Tuddenham, East.

Ordnance Map 161, new ser. (Norfolk 62, N.W.). Geologic Map 66, N.W.
In the village.
Sunk and communicated by — THUXTON, of Hethersett.
Water rose 3 feet.
Boulder Clay, to sand, 15 feet.

Tuddenham, North.

Ordnance Map 161, new ser. (Norfolk 49, S.E.). Geologic Map 66, N.W.

1. The Rectory.

Grey Boulder Clay, to light-brown sand, with water, 11 feet.

2. Cottage opposite the entrance-gates of the Rectory.

Greyish and bluish Boulder Clay, to sand with water, 15 feet.

Walpole St. Peter, including Walpole Island.

Ordnance Maps 145, 159, new ser. (Norfolk 37, 43, 44.). Geologic Map 65.

From a Report to the Local Government Board, by P. M. CROSTHWAITE, on the water supply of Terrington, Walpole St. Andrew and St. Peter, Clenchwarton and Tilney All Saints, July, 1909 :—

"A description of the water supply of this village will do for practically all the villages in the district that have not the Wisbech water laid on. There are three sources of supply available : (*a*) Shallow wells sunk to a depth of about 12 feet through gravel to clay. These wells fail in dry weather and are frequently saline. They are obviously open to serious risk of pollution as they are in many cases close to common privies." Examples are given.

"(*b*) The principal supply for drinking purposes is derived from Cisterns, in which is collected the rain-water that falls on roofs . . . .

"I was informed that in some the water rises and falls in the cisterns with the rise and fall of the sub-soil water, so that it is doubtful if they are water-tight."

"(*c*) When the above sources of supply fail the cottagers have no option but to take water from open ditches and pits."

"In many the water is salt and in none is it fit for drinking without boiling." And these ditches and pits sometimes dry up.

During his inspection of the parishes mentioned he found in all "the supply most unsatisfactory."

Walsham, North.

Ordnance Map 147 and 148, new ser. (Norfolk 29, N.W. and S.W.).
Geologic Map 68, E.

1. Waterworks. Stump Cross, south-westward end of the town. 1898.

143 feet above Ordnance Datum.

Sunk and communicated by MESSRS. TILLEY, and from J. C. MELLISS.

Well of 5 feet diameter, bricked, 20 feet. The rest a boring of 8 inches diameter, lined to 10 feet into the chalk.

Water found 60 feet down, soon rose to 58½ feet. At 66½ feet it fell to 66 feet, and on reaching the chalk to 68¼.

		Thickness. Feet.	Depth. Feet
Soil		1	—
Glacial Gravel.	Reddish yellow gravel and sand	5½	—
	Boulder flints (up to 20 inches long) and rough flinty gravel	1½	—
	Light-buff, very fine sand	22	—
	Reddish-brown sand	5	—
	Buff sand, like that above, but not so clean	3	—
	Fine gravel and sand	½	—
	Light-buff, very fine, sand	9½	48
Contorted Drift.	Pale yellow loamy sand	3½	—
	Dark reddish-brown loam, slightly mottled	9½	—
	Like the above, but lighter in colour	5½	—
	Dark reddish-brown loam, slightly mottled	5	—
	Bluish, compact, hard, stiff, loamy clay (impervious)	3	—
	Yellowish loam, with thin bands of ironstone	½	—
	Yellow loamy sand	5	80
	Dark grey, very compact sand	2½	—
	Dark brownish, greyish sand	14	96½
Till.	Dark bluish-grey, stiff, compact, loamy clay, with small stones (impervious)	4	100½
Forest Bed.	Rounded grey flints, an inch to 2 inches in diameter	6	106½

Walsham, North—*continued.*

		Thickness. Feet.	Depth. Feet.
Chillesford Beds.	Grey blowing sand	16	—
	Light grey, stiff, compact marl (impervious)	½	123
Weybourn Crag.	Grey running sand, with fragments of shells	6½	—
	The like, without shells...	10½	—
	Large flints	1	141
Upper Chalk	... ...	109	250

In describing this well (*Trans. Norf. Nat. Soc.*, vol. vii, pp. 295–297), C. REID gives a list of the fossils from the Weybourn Crag. The above classification of the beds is his.

A Report on a pumping trial, by J. N. GAVIN, gave the following results :—

Pumping begun on October 17th, 1898, at 11 a.m. and carried on continuously till 11 a.m. on October 21st, that is for 14 days.

Water-level before pumping 65¾ feet down, at end of pumping 152.

On the first day it was lowered to 145 feet.

Pumping in thousands of gallons a day, as follows :—15, 19, 25, 23, 26, 24, 24, 23, 25, 23, 26, 27, 29, 31, the differences being due to the speed of the pump. Total pumped 341,000 gallons, or a daily average of 24,400.

At the end of the trial the pump was run at an increased speed for half-an-hour, discharging 30 gallons a minute, and lowering the water-level another foot, to 153 feet down.

Half-an-hour after the pumping ceased the water-level rose to within a foot of the original level, which was regained before twelve hours.

The conditions of the supply before the waterworks were made are described on pp. 47, 48. It is satisfactory to know, from DR. J. T. C. NASH'S Report to the County Council for 1914, p. 26, that "samples of water from all the wells in the district where the main water is available were analysed, and all those houses where the analysis showed pollution now receive the supply from the mains.

According to H. W. T. EMPSON, clerk to the Council, there are two wells (besides the above noted) one of the wells being from 6 feet 4 inches in diameter to 4 feet, and 182 feet deep, the other having a bore of 13 inches diameter and 250 feet deep from the bottom of the well, or to a total depth of 432 feet. A heading of 28 feet, at the depth of 173 feet, connects the 8 inch bore with a well. The rest-level of the water is 70 feet down, but it varies whilst pumping goes on.

The White Horse Common supply is from private wells, mostly shallow.

2. New cottages "south of the word 'yard' on the (old) map." This must be about half a mile westward of the church.

Recorded by C. REID, before 1882.

Brick-earth, into pebbly gravel, &c., 40 feet.

Walsingham.

Ordnance Map 130, new ser. (Norfolk 16, N.E.). Geologic Map 68, S.W.

Town well about 50 feet deep.

The wells are mostly about 30 feet deep.

Well at Toll-bar, 60 feet deep.

Chalk near to surface.

Walsingham Rural District.

The Medical Officer reports (1912, 1913) that with the exception of the deep well at Melton Constable (see p. 101) the water-supply is got from surface-wells of varying depth. Many of these are defective in structure and liable to pollution. Of samples of water taken many were found to be contaminated. This is reiterated in Dr. J. T. C. NASH'S Report to the County Council for 1914, p. 28.

Watlington.

Ordnance Map 159, new ser. (Norfolk 57, N.W.). Geologic Map 65.

Brickyard, about a mile south-westward of the church, S.W. of the cross-roads, Fodderston Gap of the old map, Thieves' Bridge of the newer map.
Recorded by C. REID (Geology of S.W. Norfolk, 1893, p. 63).
Clay, shown in the brickyard to be Kimeridge Clay, 50 feet.
Lower Greensand, from which water rose.

The interest of this section is that "the mass of Kimeridge Clay is a huge boulder, transported from the westward;" a boulder big enough to supply a brickyard.

Watton, *see* Merton.

Waxham.

Ordnance Map 148, new ser. (Norfolk 41, N.E.) Geologic Map 67, N.

At corner of road N.E. of the church. 1879.

Water rose 3 feet.

[Glacial.]	Brown loam	10	13 feet.
[Pebbly Series.]	Sand	3	

Wayland Rural District.

The Medical Officer reports, in 1912, that the water-supply is wholly from wells, mostly shallow, and too often close to cesspits or refuse-heaps, and therefore liable to pollution, surface-water draining into the well. On analysis few supplies could be described as good.
In 1913 he adds that generally the source of pollution was in the immediate neighbourhood of the well.

Welborne.

Ordnance Map 161, new ser. (Norfolk 61, N.E. and S.E.). Geologic Map 66, N.W.

Brickyard a little more than a mile S.W. by W. of the church. Information from the foreman.

[Glacial Drift.]	Chalky Boulder Clay	14	60 feet.
	Brown sand and loam interstratified	20	
	Whitish sand	26	

Wells.

Ordnance Map 130, new ser. (Norfolk 8, N.W. and N.E.). Geologic Map 68, N.W.

In his Annual Report to the County Council for 1914 DR. J. T. C. NASH (pp. 26, 27) says :—"The water supply of the town is obtained entirely from numerous shallow wells. During the year five samples of water sent for analysis were reported unsafe for drinking purposes. Eight samples were tested by myself—five passed as satisfactory, three condemned. These results indicate that our defective drains and sewers, unpaved drainage surfaces, and the indiscriminate disposal of slop waters are beginning to have a serious effect upon the water supply." The result of an inspection of "seven yards in which there was reason to suspect probable pollution of the wells in them" was that "five of these wells were obviously liable to pollution."

Town.

Deepest well 70 feet, other wells 60 feet and less.

Farm south of old toll-gate, south-east of Railway Station.

Communicated by J. RHODES.

[Glacial Drift ?]	Gravel and sand	9	50 feet
	Chalk	41	

Reference to analyses of well-waters in the town, p. 167.

Wereham.

Ordnance Map 159, new ser. (Norfolk 69, E.). Geologic Map 65.

W. L. SUTTON writes that the well at High House is 292 feet deep, the water-level being 178 feet down.

This probably goes to the base of the Chalk, possibly into the Lower Greensand.

West Bilney, *see* Bilney.

West Dereham, *see* Dereham.

Wheatacre.

Ordnance Map 176, new ser. (Norfolk 99, N.E.). Geologic Map 67, S.

1. Board School, ⅜ mile S.E. of the church. 1877.

[Plateau Gravel.]	Sandy and gravelly brown loam ...	6	12 feet.
Boulder Clay		6	

2. Hall Farm. About 300 yards N. of church. 1911.

A 4-inch boring made and communicated by MESSRS. FAKE.

[Notes in these brackets by C. REID. From specimens from 219 feet down.]

Boring abandoned.

		Thickness. Feet.	Depth. Feet.
Soil. Mould...		3	—
[Glacial Drift] Sand and gravel with land-spring		5	8
[? Chillesford Clay] Light-blue clay		15	23
[Norwich Crag Series.]	Red sand	33	—
	Sea-sand and small sharp stones ...	1	—
	Rough red sand	14	—
	Small stones	10	—
	Fine red blowing sand	36	—
	Fine shingle	2	—
	Coarse blue sand	8½	—
	Fine blue sand. A few shells at intervals and occasional thin layers of loamy clay. [Crag shells at 219 feet]	91½	219
[Base of London Clay, or Reading Beds] chocolate-coloured clay [micaceous and sandy] ...		10	229

Another account (? of an older well, described as at Norfolk Hall Farm) from MESSRS. GIDNEY.

Shaft 14 feet, the rest bored.

Made soil	3	73 feet.
Gravel	14	
Blue clay	15	
Red sand	17½	
Gravel	6½	
Light-coloured sand...	13	
Fine gravel	4	

Whitlingham.

Ordnance Maps 161, 162, new ser. (Norfolk 63, S.E.). Geologic Map 66, N.E.

Red Barn. Sewage-farm.

For local supply. In Chalk.

108·66 feet above Ordnance Datum.

Local Government Board Return of 1915, p. 102, and note from A. E. COLLINS

Well 105½ feet, of 4½ feet diameter.

Rest-level of water 98½ feet down, when pumping 102.

Daily average supply, 3,000 gallons. Pump about 2½ hours daily, at the rate of 19 gallons a minute.

Water hard, but of high organic purity. 1911.

Winfarthing.

Ordnance Map 175, new ser. (Norfolk 105, N.W.). Geologic Maps 50, N.W., and 66, S.W.

Four wells, sunk and communicated by J. BANHAM, of Shelfhanger.

1. Dovehouse Farm. 2. The Hall road.

Both sunk 55 feet, the rest bored ; and water rose 50 feet in both.

3. Mr. Barker's, by the Mill.

Sunk 35, bored 20 feet. Water rose 30 feet.

4. Opposite the Fighting Cocks Inn.

Water rose 20 feet.

	1.	2.	3.	4.
[Boulder] Clay, to sand ...	55	80	55?	25

Three wells, sunk and communicated by G. BANHAM.

5. Near the church. Water rose 23 feet.

6, 7, for Mr. Betts. Water rose 20 and 30 feet.

		5.	6.	7.
[Glacial Drift.]	[Boulder] Clay	25	30	55
	Sand	3	3	3

8. Mr. Filby's, east of the church.

Sunk 50 feet, bored 25. Water rose 35 feet.

[Boulder] Clay, to sand, 75 feet.

The water-supply of Winfarthing is said to be very abundant and the water to rise highest where the Boulder Clay is thickest.—F. J. BENNETT.

Wolterton.

Ordnance Map 147, new ser. (Norfolk 27, N.E., and 28, N.W.). Geologic Map 68, E.

Wolterton Park. On the 100-feet contour 200 yards S.E. of the Hall.

Letter from R. J. W. PURDY, 1903.

Original well 35 feet deep. Boring made to 170 (1903). No water.

At 70 feet fragments of shell brought up, out of white Chalk (undoubtedly from Drift. There are fragments of *Cyprina islandica*. H. B. WOODWARD).

Woodbastwick.

Ordnance Map 148, new ser. (Norfolk 52, S.W. and S.E.). Geologic Map 66, N.E.

The Hall.

Made and communicated (1901) by MESSRS. ISLER and Co.

Lined with 30 feet of tubes, of 10 inches diameter, 6 feet down ; with 60 feet, of 8½ inches diameter, 3 feet down ; and with 100 feet, of 7¼ inches diameter, a foot down.

Water-level, 8 feet down. Yield, 6,000 gallons an hour. Pumping at this rate for 36 hours, on March 19 and 20, lowered the water-level only 6 inches.

		Thickness. Feet.	Depth. Feet.
Well (the rest bored)		—	4
[Drift]	Sand	4	—
	Boiling sand	56	—
	Running sand	12	78?
[? Crag]	Dark sandy clay	6	—
	Clay	6	—
	Pebbles and flints	11	101
[Upper Chalk.]	Chalk and flints	50	—
	Soft chalk	139	290

Wood Norton.

Ordnance Map 147, new ser. (Norfolk 26, S.W.). Geologic Map 68, S.W.

According to the Rev. C. Martin in seeking for water in the rectory-grounds, by means of an Abyssinian tube, "In one place we found nothing but clay. In another a blowing sand from 18 to 31 feet," and a small supply of water was then obtained.

Communicated by G. Norris, of Blo' Norton.

Different kinds of sand, 80 feet.

A communication from Messrs. Le Grand and Sutcliff, in 1888, probably refers to this well, and gives the following section :—

Drift sand	86	98 feet.
Hard blue clay	12	

Wootton, South.

Ordnance Map 145, new ser. (Norfolk 33, N.E.). Geologic Map 69.

The Rectory, about a quarter of a mile south of the church, 1905.

Communicated by Messrs. Miles and Easter (? made by Messrs. Fake).

Well 16 feet, then a boring.

Water rose to within 8 feet of the surface

Soil	3	23 feet.
Gravel	9	
Loose dark sand, with dark stones, like coprolites ...	11	

Plenty of water found in the sand, but it was contaminated with organic matter, and unfit for drinking. *See* p. 168.

There is an older well about 25 yards off.

Wortwell.

Ordnance Map 176, new ser. (Norfolk 106, N.E. and S.E.). Geologic Map 50, N.E. (described under Redenhall in the Memoir on that map).

Well in sand-pit.

Communicated by D. Palmer.

[Glacial Drift]	Sand	6	23 feet.
	Brickearth	17	

To white clay [? chalk].

Wreningham.

Ordnance Map 161, new ser. (Norfolk 86, N.E.) Geologic Map 66, S.E.

Three wells. Sunk and communicated by J. Banham.

Mr. Stannard's. Washed sea-sand, 20 feet.

Mr. Day's. Sand and gravel, 20 feet.

Mr. Batten's cottage. Black moor, 25 feet.

Wretham, West.

Ordnance Map 174, new ser. (Norfolk 94, N.W.) Geologic Map 66, S.W.

Wretham Hall. 1891.

Made and communicated by Messrs. Gidney.

Well 12 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Made soil...		2	—
[Glacial Drift]	Loam	10	—
	Light-coloured clay	25	37
[Upper]	Chalk and flints	124	161

Wymondham.

Ordnance Map 161, new ser. (Norfolk 74, S.W.) Geologic Map 66, S.W.

1—8. Wells in Drift. From J. BANHAM (J.B.) and — POOLEY (P.).

Wells in Boulder Clay.

1. Great Park Farm cottages, two miles S. of the church. Sunk 30 feet, bored 25, Boulder Clay 55 feet. Water overflowed. J.B.

2. Spooner Row, S.S.W. of the town. At the five cross-roads east of the station. Boulder Clay 57 feet. P.

3. Suton Street, S.S.W. of the town. Boulder Clay 20 feet.

Wells through Boulder Clay.

4. Burfield Hall, near. S.W. of the town. Boulder Clay, to sand and water, 56 feet. P.

5. Spooner Row, Boar's Corner. Boulder Clay, to sand, 47 feet. Water rose 40 feet. P.

6. Spooner Row, near Boar's Corner. Boulder Clay 56 feet. White sand 4. Water overflowed. P.

Wells in sand, etc.

7. Near the Boar's Inn. Clay and sand 20 feet. J.B.

8. Last house on the Kimberley road. Sand and gravel 25 feet. Marl 8. J.B.

9. Vicar Street, near the church, for the Rev. T. U. Browne. 1894.

Made and communicated by MESSRS. GIDNEY.

Shaft 10½ feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Soil		2	—
[Glacial Drift]	Loam	7½	—
	Large stone	4	—
	Blue clay	28	—
	Gravel	4	45½
Chalk and flints		105½	151

10. Co-operative Saw Mills. 1918.

Made and communicated by MESSRS. ISLER & CO.

24 feet of 8-inch pipes, 8½ feet below the surface; 119 feet of smaller pipes (? 6 inch) 6¾ feet below the surface.

Water-level in bore-hole 4½ feet down.

		Feet.
Made-up ground		3
[Glacial Drift] 103 feet	Coarse gravel	18
	Loamy gravel	4
	Coarse gravel	17
	Light-blue clay	61
	Sandy gravel	2
	Coarse flints	1
[Upper]	Chalk and flints	—

Yarmouth.

Ordnance Map 162, new ser. (Norfolk 66, S.E., 78, N.E.) Geologic Map 67, N.

From Report by W. LEE to the General Board of Health, 1850, pp. 27, 28 :—

"The inhabitants are dependant on wells and rain-water. . . . With such a soil (absorbent), and the water at that depth only (near the surface), it is impossible in a town to preserve the wells from pollution; and that pollution must inevitably go on increasing, as the subsoil becomes entirely saturated with organic matter by the infiltration of the refuse from the surface. . . . Out of the immense number of well-waters that I examined . . . I only found one that I could say was free from organic matter."

"The *Middle Denes Well*, or Dutch well, is probably more resorted to than any other. It is situated in an open space of ground, which has houses on two sides of it. The ground at the well is lower than the houses, and the drainage from the

Yarmouth—*continued.*

houses flows over the land towards the well. This well is not covered, and two persons have drowned themselves in it within three years. Dead animals are sometimes found in it."

"Great numbers of the pumps in Yarmouth are placed against the walls of privy cesspools, and very many between two privies. In fact, contiguity to the privy seems the rule."

Many other examples are given. But now, of course, there is a good public supply.

F. SUTTON has noted this town as an "instance of peculiarity in its well waters. The wells are all extremely shallow, brackish, and loaded with pollution of an animal origin, as is shown by the enormous proportions of nitrogen (in their waters), existing partly in the organic state, but very largely as nitric acid, being oxidised into this condition very quickly by the sands in which the water is accumulated." *Proc. Norwich Geol. Soc.*, 1879, pt. iii., p. 90.

1. Messrs. Baly, Sutton & Co.'s Manure Works. 1869.

Communicated by the manager, with a tube of specimens, from a depth of 16 feet to the bottom.

Boring of 1½ inches diameter.

Water overflowed the top of the pipe, which was 4 feet above the ground, for three or four days. The water was bluish, and the sediment from it sandy. It was used for six or seven years, but was given up on account of stones and sand being constantly pumped up.

[Recent and Estuarine Deposits.] Shelly brown sand, with a little loam and soil at top, 70 feet.

The uppermost and the lowermost samples of the sand are the darkest. Small fragments of shells occur, and are plentiful in the upper and lower specimens, a piece of *Cardium* being identifiable near the bottom of the tube. J. H. BLAKE.

2. Lacon & Co.'s Brewery. 1840.

In the yard, which is 20 feet above Ordnance Datum.

Shaft 22 feet; the rest bored.

The following description is that given by PRESTWICH (*Quart. Journ. Geol Soc.*, 1860, vol. xvi., pp. 450, 451, slightly condensed.—W. W.), based upon his examination of specimens. These are preserved at the brewery, in the box originally made for them, which contains three trays divided into compartments, on each of which is recorded the depth at which the specimen in it was obtained. Through the courtesy of MR. NIGHTINGALE I carefully examined all these with Prestwich's account in my hand.—J. H. BLAKE (1890).

"One column," says PRESTWICH, "gives the specimens as read off previous to my having formed any definite conclusion; and in another column is added the geological structure which the examination of the specimens in conjunction with the coloured section led me to surmise. From the nature of the work, the shells are necessarily small or fragmentary."

		Depth Feet.
Blown sand and shingle ... ... about		50
Recent Estuarine Deposits. 120 Feet.	Coarse light-coloured sand, with 1 specimen of *Ostrea edulis*, 2 of *Cardium edule*, 1 each of *Corbula nucleus* [*gibba*], *Tellina balthica*, and *T. planata*	58
	Light-grey clay, with a few pebbles of quartz, fragments of *Cyprina islandica*, 1 *Tellina*, and 1 fragment of *Pecten opercularis*	109
	Yellowish shelly sand, with fragments of small *Tellinæ*	111
	Fragments of shells	113
	Light-coloured shelly sands	123
	Light-grey shelly sands	150
	The same, coarser, with concretions and a few flints	156
	Laminated micaceous grey clay	158
	Light-brown clay	160
	Grey clay and sand, with shells; *Tellina*, 1 fragment of *Mytilus edulis*	161
	Grey clay, with undeterminable fragments of shells; 1 valve of *Balanus*	166

Yarmouth—*continued.*

		Depth. Feet.
London Clay. 310 Feet.	Light-brown clay and two small light-coloured concretions	170, 180
	Tough brown clay	190
	The same, slightly greyer, with one concretion	200, 210
	The same, slightly variegated	220
	Brownish-grey clay	230
	Dark-grey clay	240
	The same, with 2 lumps of iron-pyrites and 2 small calcareous concretions	240-50
	Grey clay	250
	The same, darker and more compact	260, 270, 280
	The same, browner; iron-pyrites	291
	The same, with wood and decomposing iron-pyrites	294
	Brown clay	300
	Light-grey sandy clay	309
	Greenish sandy clay	320
	Streaked brown clay	330
	Greyish-brown clay	340
	Micaceous sandy clay	350
	Greyish-brown clay	358
	Micaceous sandy clay	370
	Brown sandy clay	380
	Grey clay, with decomposing iron-pyrites	389
	Brown clay	390, 400
	Brown micaceous sandy clay	410
	Brownish sandy clay	420, 430
	Dark-brown sandy clay	440
	The same, with soft green grains	450
	Tough brown clay	460, 470
	Fragments of soft septaria	475
Reading Beds. 46 Feet.	Grey clay, with lignite	480
	Tough brown clay	490
	Streaky dark-grey clay	500
	Grey clay and green sand	505
	The same, more mixed	510
	The same, with more green sand	515
	The same, with less green sand	520
	Pure dark-green sand	525
	The same, more clayey, and with small dark green-coated flints	526
[Upper] Chalk with flints, 70 feet [? 71]		597

The thickness of Chalk pierced has inadvertently been given as 57 feet in Prestwich's description. I was informed at the brewery that the boring reached a depth of either 596 or 599 feet.—J. H. B.

Presumably the thicknesses assigned to the geologic formations were taken from the "well-executed coloured section" of which PRESTWICH speaks, as they do not agree with the depths above given. Naturally the specimens may not show the bottom of any formation.—W. W.

S. V. WOOD, Junr., has suggested that the beds above the London Clay might be a prolongation of the Cromer Drift; but the shells do not go with this.—*Geol. Mag.*, 1867, vol. iv., p. 560.

In W. LEE'S Report (see above), SIR E. LACON says (p. 30) that the brewery was supplied from two wells, one on the premises, the other about 600 feet off, across the market-place. The average consumption was 180,000 gallons a week. One well is of 20 feet diameter and 16 deep, the other from 10 to 15 feet diameter and 16 to 20 deep. "In summer we often used to pump the neighbouring wells dry, before we sunk the large well." Now (1849) with the two working there is less effect.

TRIAL-BORINGS, NOT FOR WATER.

A number of shallow borings, put down for various purposes other than water-supply, have been recorded in some of the Geological Survey Memoirs, and it will be enough here to refer to these. Others that have not been published are given in detail afterwards. None, however, are of any special interest.

In the Memoir on Sheet 65 are accounts of the following :—

Lynn.—For proposed sewerage-works, 10 borings.
Magdalen Bridge, 1 boring.
Nar Valley Drainage, 6 borings.

In the Memoir on Sheet 67 two borings, both made by the Geological Survey, for testing the beds along the coast, at *Winterton* and at *Ormesby St. Margaret* (Scratby). In both the sand or gravel at the bottom was full of water.

Details of borings at the Breydon Viaduct, Yarmouth, are given in *Proc. Inst. Civ. Eng.*, 1904, vol. clvii., p. 268.

Lynn.

Gasworks. Trial-holes. 1897.

Made and communicated by MESSRS. TILLEY.

The whole in Alluvial beds.

	Thicknesses in feet. 1.	2.	3.
Subsoil	1	1½	1
Loam and silt (little water)	5	3½	—
(or Loam, little water)	—	—	6
Blue clay	6	5	6
Peat	2	2	2
Blue clay	1½	1	2
Peat	½	1	½
Blue clay	10	9	8½
Peat	½	½	—
Sand (little water)	3½	3	3½
Black clay	1½	—	1½
Peat	1½	—	—
Black clay	3½	—	—
Total	36½	26½	31

These show a persistence of beds with one exception, and a slight variation in the thickness of beds.

Yarmouth.

Town Hall.

Communicated by the TOWN SURVEYOR, Sept., 1901, to C. E. HAWKINS.

Made ground	6	60 feet.
Ooze, or silt with decaying vegetable matter	14	
Boulders and gravel, with lumps of hard clay	40	

The following notes on borings, made by the Geological Survey, are from C. REID'S interleaved copy of the Cromer Memoir, and are of geologic interest :—

On Oct. 12th, 1886, a boring was made at half tide-level south of *Mundesley*, a chain south of the hedge close to the last house. It commenced immediately

Yarmouth—*continued.*

below a mass of rough gravel and pan, forming the base of the Forest Bed. It was carried down 22 feet in alternately stiff or sandy dark blue very micaceous clay, without fossils. Owing to breakage of the tools it could not be carried lower.

Next day a boring was made 11 chains north of *Happisburgh Gap*, nearly opposite the church, at about high water-level, close to the cliff. The section was

Till			
Forest Bed	Sandy clay and sand in cliff ...	2½	24½ feet.
	Sandy clay and sandy gravel ...	4	
Weybourn Crag or Chillesford Clay.	Dark blue clay and sandy clay ...	17½	
	Very micaceous blue sand	½	

The boring was stopped by quicksand, reached at 21½ feet. No fossils were found.

In both these borings the clays were very micaceous, the mica often in flakes of considerable size.

The other borings made on the Norfolk coast did not go below the base of the Forest Bed. There is, therefore, a distance of 30 miles, between Happisburgh and Pakefield Lighthouse, in which the base has not been reached.

A boring north of *Pakefield Lighthouse Gap* showed the following section :—

Laminated light-blue and ferruginous micaceous clay...	13½	18 feet.
Brown loamy sand, with thin seams of light-blue clay	3	
Sand, full of water	1½	

The beds seem to correspond with those of Happisburgh, but are more weathered.

Whilst this Memoir was passing through the press a Note on a boring in Norfolk, by J. PRINGLE, was published.(1) The site is about four-fifths of a mile south of West Bilney. It passed through 19½ feet of superficial deposits, 111 of Lower Greensand (of which details are given) and 153½ of Kimeridge Clay.

(1) Summary of Progress of Geological Survey, for 1919, published 1920.

ANALYSES OF SPRING WATERS.

Of the few analyses of water from springs, two are old ones, of reputed mineral springs, and the rest are mostly from three springs, or sets of springs that are used for supply. None are new.

Alphabetic arrangement, by the names of places, is again followed.

Diss.

The water of the Mere [Chalk-springs].

By C. HATCHETT. *Phil. Trans.*, 1798, vol. lxxxviii., pp. 574, 575.

300 cubic inches of the water, gently evaporated, left a pale brown scaly substance, weighing 58 grains. This yielded, in grains :—

Muriate of lime	18
Muriate of soda, with a very small portion of sulphate ...	10
Selenite	1·7
Alumine, with a portion of iron too small to be estimated...	1·5
Carbonate of lime	21
Carbon, with a little siliceous earth	3·5
	55·7
Loss	2·3
	58

The water had a yellowish tinge, a rather saline flavour, but no odour.

Grimston, etc.

The following set of analyses of waters from the notable springs in this neighbourhood (*see* pp. 30–32) were made by WM. JOHNSTONE, and published in his pamphlet "The Water Supply of Lynn," 1880.

Instead of treating of each spring separately it will be useful to combine the analyses, by which means comparisons can be more readily made. The first, at Well Hall, is in the parish of Gayton ; Nos. 2 to 5 are in Grimston ; the sixth, Roydon Spring, has no precise locality given, and may also be in Grimston. It seems to come from a different source. The other springs are all from the Chalk.

All the samples were taken on July 3rd, 1880, and in the middle of the day (from 11.15 a.m. to 1.30), except in the case of the Roydon Spring, which was taken at 4.10 p.m.

A sample was also taken from the mains (? in Lynn) on July 1st, 1880, at 11.15 a.m., and the analysis of this is given for comparison with those of the various sources.

All exercised on litmus-solution an alkaline reaction, decided in all but Well Hall, in which it was less distinct.

Grimston, etc.—*continued.*

——	Suspended Matter.	Colour, etc.	Taste.
Well Hall ...	None	Clear and sparkling.	Pleasant and refreshing.
Sow's Head ...	„	Clear, transparent and sparkling.	Cool and refreshing.
South Spring	Light-brown, flocculent, organic	Pale blue ...	Slightly saline.
North Spring	„ „ „	„ ...	Saline.
Water Lane ...	None	Clear and sparkling.	Good.
Roydon Spring	White, flocculent, organic ...	Satisfactory	Satisfactory
From Main ... (smell unpleasant.)	Swarming with living animalculæ and decomposing animal and vegetable remains.	Dirty opaque, yellow.	

It should be remembered that the old surface-supply was drawn on from the main, the new well-supply not having been established until several years later.

Grimston, etc.—*continued.*

—	Well Hall.	Sow's Head.	Grimston Church. South Spring.	Grimston Church. North Spring.	Water Lane.	Roydon Spring.	From the Mains.
In grains per gallon.							
Total solid matter	24·99	24·01	27·16	25·9	23·52	21·42	21·56
„ saline „	23·57	22·54	23·17	22·64	22·458	14·627	18·096
„ organic „	1·41	1·47	3·99	3·26	1·062	6·793	3·464
„ saline matter precipitated by boiling	19·477	19·1	19·495	18·87	19·311	8·79	12·882
„ „ „ not precipitated by boiling	4·093	3·44	3·685	3·76	3·149	5·837	5·214
Nitrogen as nitrates and nitrites	·302	·249	·5762	·6746	·275	·5283	·4862
In parts per million.							
Free ammonia	·0016	·005	·012	·04	·001	·04	·01
Albuminoid ammonia	·004	·0054	·084	·15	·005	·134	·116
Dissolved gases, in cubic inches.							
Oxygen	4·26	4·07	2·81	2·71	4·07	3·82	3·94
Nitrogen	11·12	11·14	6·27	6·03	8·34	9·01	11·56
Carbonic acid	·95	·56	3·34	3·18	2·13	·43	2·04
Total	16·79 (·33)	15·77	12·42	11·92	14·54	13·26	17·54
Complete analysis of saline ingredients (*in grains per gallon?*).							
Calcium carbonate	18·156	18·135	18·359	17·704	18·311	7·629	10·488
„ sulphate	1·178	·824	·854	1·07	·896	3·062	2·147
„ phosphate	·032	·026	·024	·025	·03	·037	·029
Magnesium carbonate	·402	·388	·568	·587	·499	·524	1·6
Sodium chloride	2·255	2·354	2·559	2·513	2·006	2·477	2·867
Potassium „	trace	trace	trace	trace	trace	trace	trace
Ferrous carbonate	·301	·225	·218	·195	·24	·278	·451
Silica	1·246	·588	·588	·546	·476	·63	·514
Hardness, temporary	18·55	18·52	18·92	18·92	18·81	8·15	12·
„ permanent	2·47	1·8	1·85	2·07	1·89	4·06	2·5
„ total	21·02	20·32	20·77	20·36 (·99)	20·7	12·21	14·5
Temperature of air (Fahrenheit)	60°	65°	60·5°	60°	59°	59°	70°
„ water „	52°	52°	51·5°	50°	51·5°	54°	65°

Grimston, etc.—*continued.*

Of the South and North Springs, at Grimston, Mr. Johnstone says: "There is a considerable difference between the results obtained, and although the springs are so close to one another they cannot be regarded as one and the same water. The free ammonia in the North spring is high, whereas in the South spring it is of reasonable amount, and the albuminoid ammonia in the North spring is very high and also high in the South spring, and taking all things into consideration . . . I am decidedly of opinion that the drainage from the *graves* and the surface-water of the church-yard are contaminating the springs, as the church-yard is immediately to the rear of the springs, and also . . . above them."

"The use of these waters is, therefore, decidedly to be avoided for drinking and household purposes."

The Sow's Head and Water Lane waters are described as first-class and inferentially that of Well Hall.

Of the Roydon Spring he says: "The carbonaceous organic matter is exceedingly high, and taking into consideration that the free and albuminoid ammonia are also high, there can be no other conclusion arrived at but to condemn it as a highly dangerous water, and totally unfit for domestic use."

"Typhoid fever has been prevalent among the people who reside in the vicinity of the spring, and who constantly use the water."

? Sow's Head Springs.

By Prof. P. F. Frankland. 1892. In Report to the Local Government Board. No. 63, p. 14.

In parts per 100,000.

Total solid matter	29·2
Organic carbon	·031
Organic nitrogen	·009
Ammonia	0
Albuminoid ammonia	0
Nitrogen as nitrates and nitrites	·599
Total combined nitrogen	·608
Chlorine	1·15

Hardness: temporary, 15·3; permanent, 5·3; total, 20·6.

Clear, palatable. The mineral nitrogen, in the form of nitrates, is in no way excessive for spring-water. A first-class water for drinking.

Hunstanton.

1. Public supply. *See* p. 55.

G. W. Wigner. The Water Supply of Sea-side Watering-places, 1878, pp. 2, 3, 176, 177.

"The water is said to be pumped from a chalk well about 14 miles from the sea": but that error is corrected on pp. 33, 136, where the water is credited to springs from the Lower Greensand, and we are told that 14 was printed instead of ¼.

A. From a tap in a house. B. From the mains.

In grains per gallon.

	A.	B.
Total solid matter	25·3	26·5
Loss of ignition, after deducting combined carbonic acid.	6·92	2·03
Lead and copper	Very minute traces.	None.
Iron	Heavy traces.	Heavy trace.
Chlorine, calculated as chloride of sodium	3·69	3·51

Hunstanton—*continued.*

	A.	B.
Nitrogen, as ammonia	·0038	·0053
„ „ albuminoid ammonia... ...	·0032	·0069
„ „ nitrates	—	·63
„ „ nitrites...	·0086	Traces.
Total nitrogen, in the four forms... ...	—	·6422
Oxygen absorbed by organic matter ...	·028	Traces.
Hardness before boiling, Clark's scale ...	16°	16°
„ after „ „ „ ...	9°	9·7°

A. Colour: "A dirty opaque yellow, due to a heavy trace of suspended matter, showing the necessity for filtration."

Microscopic examination "satisfactory, and did not indicate the presence of any animal contamination. The sample was free from objectionable taste or smell."

B. Free from the suspended matter found in A. four months before, "and the colour has improved from a dirty yellow to a good pale blue . . . on the whole this sample is better."

2. A later analysis of the water from the Urban District Council's Waterworks.

By F. Sutton and Son. June 1911.

In parts per 100,000.

Total solids in solution	36·5
Ammonia, free	Nil.
„ albuminoid	Nil.
Chlorine	2·85
Nitrogen as nitrates	·8
Nitrites	Nil.
Oxygen absorbed in 4 hours	·004
Alkalinty, as Ca Co_3	21·43

Hardness, before boiling, 22·71; after boiling, 6·71.

A water of exceptional organic purity, free from all trace of pollution. Distinctly hard, the permanent hardness rather higher than the average in Chalk waters of the district.

Marham.

Wisbech Water Works. *See* p. 55.

A. By J. W. Knight, April 1903. B (marked D well), by A. H. Lowe, 1901.

Both in grains per gallon.

	A	B
Total solid matter	16·	—
Total dissolved matter at 110° C.	—	29·4
Chlorine...	1·3	1·5
Equal chloride of sodium	2·14	—
Nitrates (as nitrogen)...	·7	·12
Nitrites	—	None
Free ammonia	·0007	·0015
Albuminoid ammonia	·0049	·002
Oxygen absorbed by organic matter in 15 minutes, at 140° F....	·028	—

A. Appearance in two-foot tube, pale blue. Smell when heated to 100° F. none. Metals none. Microscopic examination, no deposit. Total solid matter, chlorides and nitrates low. Ammonia and oxygen absorbed all low, showing absence of organic matter. Water unpolluted and fit for drinking purposes.

B. Hardness, temporary, 12·6°, permanent, 4·6°, total 17°. Appearance bright, no suspended matter. Smell none. The solids are of the usual composition in hard well-water, and consist chiefly of lime-carbonate with a little lime-sulphate and traces of magnesia. A typical sample of hard spring-water of great organic purity, well fitted for drinking and other domestic purposes.

Shelfhanger.

The Shelfhanger Mineral Water.

From a printed Circular. By — TICHBORNE.

In grains per gallon.

A chalybeate, peculiar in its composition. The antacid properties may be said to be almost entirely due to carbonate of magnesium, and although the amount of strong purgatives (Glauber's and Epsom salts) are next to nothing, yet this water will have a slight laxative character, owing to its magnesium salts being in preponderance. The astringent character, therefore, of the iron seems to be fairly balanced. (Condensed from printed circular.)

Carbonate of magnesium	23·58
Carbonate of calcium	2·45
Carbonate of iron (ferrous salt)	2·9
Chloride of magnesium	4·81
Sulphate of magnesium	·49
Sulphate of calcium	1·2
Sulphate of sodium	3·
Ammonia chloride	1·7
Albuminoid ammonia, trace (·016 ? parts per 100,000).	
Nitrates and nitrites (equal to N_2O_5)	·079
Silica	·21
Total solids	40·419

Thetford.

Water of the Mineral Spring. *See* p. 36.

By P. ACCUM. Before 1819.

In grains per gallon.

Carbonate of iron	2·75	
Muriate of magnesia	3·25	
„ „ lime	2·25	
Sulphate of magnesia	1·25	
Muriate of soda	2·125	
Sulphate of lime	3·	
	14·625	
Carbonic acid gas	12·07	cubic inches.
Oxygen gas	1·21	
Atmospheric air	3·04	
	16·32	

ANALYSES OF WELL-WATERS.

We have but few complete mineral analyses of waters from wells, which of course is the sort that is specially wanted by the geologist, most analyses having been made for health-purposes only, and for these we have largely to thank the County Analysts, Messrs. Sutton.

The following seem to be new, that is to say, unpublished before: Cromer (? Nos. 3–6), Diss, Feltwell, Gayton, Hockwold, Holt, Metton, Roudham, Rushford, Sheringham, Swanington, one of doubtful site, Thetford, Trimingham, Trowse, North Walsham, Whitlingham, South Wootton.

Aylsham.

Soame Memorial Well. *See* p. 60.

Made by Messrs. Sutton, April 20th, 1912.

Ammonia, free	Nil.	
„ albuminoid	Trace.	
Nitrates	·084	grains
Chlorine	2·2	per gallon.

Bintree.

Manor House. *See* p. 62.

By F. Sutton.

In grains per gallon.

Saline ammonia	Faint trace
Albuminoid ammonia	·0016
Combined chlorine	1·65
Nitrogen as nitrates	Nil
Nitrites	Nil

Hardness before boiling, 19°.

The water is of good organic purity and free from all trace of pollution by surface-, or sewage-impurity. It is of excellent quality for drinking and general domestic purposes.

Bungay.

From the Public Pump in Earsham Street, after a boring had been carried down into the Chalk.

Made by H. S. Coupland, October, 1901.

In grains per gallon.

Total solid matter	129·5
Chlorine in chlorides	35·
Ammonia, free	·025
„ albuminoid	·007
Nitrites and nitrates, phosphates, lead	Absent.

Hardness, temporary, 23·6°; permanent, 16·4°.

Condensed Remarks.—The amount of solid matter in the water is large, due to the geological formation through which it has passed. Free ammonia is also high, but this is not taken as evidence of organic impurity, seeing that albuminoid ammonia is about the average, and nitrites, etc., are absent. It is not unusual to find a large proportion of free ammonia in unpolluted deep well waters. The sample contained some suspended matter, and there was a deposit in which traces of iron were found. If the water can be pumped up clean it will be suitable for drinking purposes. [The analyst seems to me to take a rather too favourable view.]

This Suffolk record was printed by mistake; but as it is from a border-town it is left in.

Cantley.

Anglo-Netherland Sugar Factory. *See* p. 69.

Made and communicated by W. L. SUTTON. 1. July 10th, 1912. (Sample taken June 29th.) 2. September 7th, 1912. ? From a second well.

In parts per 100,000.

	1.	2.
Ammonia, saline...	·039	Nil
Ammonia, albuminoid	·001	·004
Chlorine	7·71	5·85
As NaCl.	12·7	9·64
Nitrogen as nitrates	Nil	3·02
Nitrites	Nil	Nil
Oxygen absorbed in four hours at 80°F. ...	·012	·025
Lime	12·34	21·85
Magnesia	2·11	1·92
Sulphuric anhydride	4·63	6·04
Total solids in solution, probably combined as under:—	47·5	67·97
Silica, iron, and alumina	1·72	8·5
Soda	7·52	5·82
Potash	1·27	1·32
Alkalinity, as carbonate of lime	24·28	28·
Hardness, total	24·85	38·85
Hardness, permanent	5·14	17·28
Calcium carbonate	22·04	28·
Magnesium carbonate	1·92	—
Magnesium sulphate	3·54	—
Calcium sulphate	—	10·27
Sodium sulphate	1·91	—
Potassium sulphate	2·35	—
Sodium chloride	12·7	—
Calcium chloride	—	3·88
Magnesium chloride	—	4·52
Potassium nitrate	—	2·84
Sodium nitrate	—	15·96
Silica	1·42	
Iron and alumina	·3	2·5
Combined water, and undetermined	1·32	

1. Opalescent, from suspended chalk. Slight tarry odour. A typical Norfolk Chalk-water, somewhat affected by slight marine influence, the chlorides, sulphates and permanent hardness being in consequence slightly higher than usual. The water is of great organic purity, and the total hardness is normal. Fit for drinking purposes.

2. Clear. Of fair organic purity, and free from immediate pollution by sewage or surface-impurities. The salient feature is the high figure for nitrates, showing that the surrounding soil is or has been subject to pollution by animal impurities. Such a supply is of inferior quality for drinking purposes, although not immediately dangerous.

Creake, South.

Ordnance Map 130, new ser. (Norfolk 15, N.E.). Geologic Maps 69 and 68, S.W.

Vicarage. Shallow well in Chalk?

Riv. Poll. Comm. Sixth Rept. 1874, p. 83.

February 5th, 1873.

In parts per 100,000.

Total solid impurity	32·92
Organic carbon	·255
Organic nitrogen	·103
Ammonia	·016
Nitrogen as nitrates and nitrites	·639
Total combined nitrogen	·759
Previous sewage or animal contamination*... ...	6,200
Chlorine...	2·8
Hardness, temporary	17·2
Hardness, permanent	6·4
Hardness, total...	23·6

Slightly turbid, palatable.

* An old term, not now used, based on the idea that all nitrates and ammonia are derived from sewage.

Cromer.

1. From three wells.

G. W. Wigner. The Water Supply of Sea-side Watering-places, 1878, pp. 51–53.

At that time there was no regular public supply, and the samples of water from two of the three public wells sent to him showed "a wretched state of water-supply."

A. Town Pump. B. Baker's Pump. C. Private Well.

In grains per gallon.

	A.	B.	C.
Total sold matter	146·7	32·1	39·8
Loss on ignition, after deducting combined carbonic acid	29·62	10·07	3·2
Lead and copper	None	None	None
Iron	Slight trace.	Traces	Very slight trace.
Chlorine, calculated as chloride of sodium	48·91	5·73	6·9
Nitrogen, as ammonia	·0018	·0036	·0016
„ „ albuminoid ammonia ...	·0076	·0095	·0055
„ „ nitrates	5·95	1·26	1·61
„ „ nitrites	Traces	Traces	Traces
Total nitrogen in the four forms ...	5·9594	1·2731	1·6171
Oxygen absorbed by organic matter ...	·072	·104	·07
Hardness before boiling, Clark's scale	54·4°	13·5°	19·9°
„ after „ „ „	40·8°	7·3°	9·°

Of A and B he says: "These waters are both, to say the least, interesting specimens. They would be more interesting if I could forget that the health of some hundreds of people is being imperilled by them."

"The town pump water is of a yellow-green colour with very offensive smell, and a nauseous taste of salt and nitrate of soda. It swarmed with animalculæ . . while the residue showed crystals of urea, as well as alkaline urates. This so called water is concentrated but fairly oxidised sewage."

"Baker's pump water is a little better, but still bad. It is full of animalculæ, has a dirty colour, offensive smell, and putrid taste. The nitrates are lower, but still sewage is the only name by which it can be called."

Of C he says: "The colour was dirty green and the smell offensive, while the taste was nauseous in the extreme."

These condemnatory remarks are also given, in a different form, on p. 61.

Cromer—*continued.*

2. Waterworks Co. (Cromer well, *see* pp. 73–75).

By F. SUTTON, November, 1880.

From a printed slip, and in *Rep. Brit. Assoc.* for 1883, p. 155.

In grains per gallon.

Total dissolved solids	21·28
Free ammonia	·0056
Ammonia from organic matter	·0028
Nitrogen as nitrates or nitrites	None
Chlorine (= common salt 3·71)	2·24
Lime	7·28
Magnesia	·605
Sulphuric anhydride (=gypsum 2·45)	1·44
Oxygen required to oxidise organic matters ...	·076

Natural hardness 15°. Hardness after boiling 3·8°.

"Undoubtedly to be ranked as a water of high-class purity . . . admirably adapted for dietetic purposes. The organic impurity is practically *nil*, and the mere trace which is . . present is unquestionably mainly derived from vegetable sources of a perfectly harmless description."

G. H. OGSTON confirms the above, in January, 1881, and adds that the sample sent him "is clear and bright. . . The analysis indicates that it is entirely free from pollution."

3. Waterworks. From tap at Hôtel de Paris (Cromer well).

By F. SUTTON, October, 1897.

In grains per gallon.

Ammonia, free	Nil
„ organic	Nil
Chlorine...	2·9
Nitrogen as nitrates	Nil
Oxygen required	·0112
Lime	7·84
Magnesia	2·16
Sulphuric anhydride	1·28
Oxide of iron	·002
Silica and alumina	1·05
Total solids in solution	29·47

Hardness, Clark's scale, before boiling 16°. After boiling 4·5°.

Colour good. No deposit on standing.

A separate sample from the well gave a slight chalky deposit on standing, with no organic forms present.

4. Waterworks. A. From reservoir. B. From tap in office.

By [SIR] W. CROOKES and [SIR] J. DEWAR, 1899.

In grains per gallon.

	A.	B.
Total solid matter	25·4	26·2
Chlorine (= chloride of sodium 4·838)	2·952	2·952
Nitrogen as nitrates and nitrites	0	0
Nitrogen as ammonia	0	0
Oxygen required to oxidise organic matter ...	·015	·015
Organic carbon (in parts per 100,000)	·036	·032
Organic nitrogen „ „ „	·01	·01

Hardness 19·68°, in both, reduced to 6·69° and 5·6° after boiling a quarter of an hour.

In both: Appearance, clear; Colour, good; Odour, none; Reaction, neutral; Colour of residue, white.

"The latest results show an average of 67 microbes per cubic centimetre. Pathogenic organisms absent."

Cromer—*continued.*

5. Waterworks (Cromer well).

Made and communicated by Dr. J. C. Thresh, April, 1899

In parts per 100,000.			Probable combinations.		
Ca.	...	8·45	Calcium carbonate		19·3
Mg.	...	·35	Magnesium carbonate		2·55
Na.	...	2·85	Magnesium sulphate		1·75
CO_3	...	11·6	Sodium sulphate		·75
SO_4	...	3·7	Sodium chloride		6·6
Cl.	...	4·	Silica, etc.		1·55
NO_3	...	·09			
			Total solid constituents, dried at 180° C.		32·5

Free ammonia	·002
Organic ammonia	0
Oxygen absorbed in 4 hours at 27° C.	·016
Nitrites	Nil

Hardness, temporary, 14° ; permanent, 5° ; total, 19°.

6. Public Supply.

Analysis made at R. Inst. Public Health, April, 1908.

Sample from Main in engine-house, leading direct from pumping sumph. A composite water therefore (Cromer and Metton wells).

Colour in 2-ft. stratum, yellowish-green.

Reaction, neutral.

Suspended matter, faint traces.

In parts per 100,000.	
Total solids dried at 100° C.	30·
Lost on ignition, after re-carbonating	1·
Chlorine (= sodium-chloride 4·7)	2·9
Nitrites, as N_2O_3...	Absent
Nitrogen as nitrates	·03
Saline ammonia	·008
Albuminoid ammonia	·002
Oxygen absorbed in 3 hours at 37° C.	·025
Poisonous metals (lead, copper, iron)...	Absent

Hardness, temporary, 13·6° ; permanent, 5° ; total, 18·6°.

A good water, but the saline ammonia somewhat high.

See also **Metton.**

8. Grays Well.

Made by F. Sutton, 18th August, 1866.

In grains per gallon.		
Carbonate of lime	15·43	
Carbonate of magnesia	4·18	
Sulphate of lime	62·96	
Sulphate of soda	8·02	
Sulphate of magnesia	1·56	117·57
Chloride of potassium...	7·77	
Carbonate of iron	9·25	
Chloride of sodium	7·71	
Silica and alumina	·69	

Dereham, East.

1. Water from well 17 feet deep. February, 1903.

2. „ „ „ 180 „ „ August, „ (? waterworks).

Made and communicated by W. T. BURGESS.

In parts per 100,000.

	1.	2.
Total solid residue...	40·16	37·
Organic carbon...	·180	·056
Organic nitrogen	·019	·005
Ammonia, free	·001	0
Ammonia, albuminoid	·007	·0013
Nitrogen as nitrates	1·870	Trace
Nitrogen as nitrites	0	Nil
Total combined nitrogen	1·890	·005
Oxygen absorbed in 4 hours at 80° F.	·058	·023
Chlorine	2·8	2·45
Hardness, total, by soap-test	23·	30·3
Hardness, permanent	9·7	3·2
Hardness, temporary	13·3	27·1
Iron (equivalent of Fe_2O_3)	—	2·4

1. Turbid.

2. Very turbid with hydrated oxide of iron.

3. In the annual report of the Medical Officer of Health (H. B. VINCENT) for 1881, the following analyses of waters from different and widely distant parts of East Dereham are given with the object of showing the superiority of the water from the Local Board's well. The right column has been added.

By F. SUTTON.

In parts per 100,000.

—	Pump Well by Assembly Rooms.	Rev. W. Freeman's Well.	Colonel Bulwer's Well.	Mr. Fison's Well at Maltings.	Local Board's Well.	
Free ammonia ...	·002	·004	·004	·003	·02	·0098
Organic Nitrogen, as Albuminoid Ammonia ...	·009	·009	·008	·005	·003	·0014
Chlorine	5·9	3·8	4·1	3·6	1·5	·735
Nitrogen as Nitrates and Nitrites ...	1·54	1·12	·574	·71	0	0
Iron...	—	—	—	—	trace	—
Total Solid Matters in Solution ...	74·8	60·4	60·6	56·2	22·	10·78
Hardness (Clarke's scale) total	36 deg.	35 deg.	31·5 deg.	33 deg.	16 deg.	
After boiling for half-an-hour ...	11·7 deg.	9·2 deg.	6·2 deg.	7·8 deg.	4 deg.	

Diss.

1. By F. and W. L. Sutton. January 24th, 1901.

Appearance clear ; odour and colour good.

In grains per gallon.

Free ammonia	·0021
Albuminoid ammonia	·0014
Nitrogen in nitrates	·49
Nitrites	Nil
Chlorine in chlorides	4·9
Solids in solution dried at 212° F.	52·5
Oxygen absorbed in 4 hours at 80° F.	·07
Poisonous metals	Nil
Hardness before boiling	31·5°
„ after „	11·0°

This water is practically free from any trace of organic impurity or anything dangerous to health, and we are of opinion that it is suitable for the manufacture of aerated waters.

2. For the Urban District Council. Boring of 400 feet.

By Messrs. Sutton, October, 1910.

(Samples taken 30th September, 1910.)

In parts per 100,000.

Chlorine	8·57
Nitrogen as nitrates	Nil
Nitrogen as nitrites	Nil
Lime	29·4
Magnesia	4·64
Sulphuric anhydride	18·86
Silica, iron, aluminia, etc.	2·8
Alkalinity as carbonate of calcium	38·
Soda	6·16
Hardness before boiling 61, after boiling 21.	
Total solids in solution, probably combined as below	87·93
Calcium carbonate	37·85
Calcium sulphate	19·48
Magnesium sulphate	11·13
Magnesium chloride	2·07
Sodium chloride	11·6
Silica, iron, alumina, water of combination, etc.	5·8

3. Messrs. Young, Crawshay & Young's Crown Brewery (*see* p. 81).

Appearance bright and clear. Odour and colour excellent.

	Grains per gal.
Free ammonia	·0077
Albuminoid ammonia	·0021
Nitrogen in nitrates	·024
Nitrites	Nil.
Chlorine in chlorides	3·700
Solids in solution	37·
Oxygen absorbed in four hours at 80°F.	·03
Poisonous metals	Nil.

Hardness before boiling 23·2, after boiling 8·2.

Remarks.—This water is of excellent quality for domestic or brewery purposes. No trace whatever of sewage or other pollution.

Docking Rural District, N. and W. parts.

By F. and W. L. Sutton. Shortened from the Table in Dr. Fletcher's Report to the Local Government Board, No. 294, 1907, p. 11.

In grains per gallon.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen in Nitrates.	Nitrites.	Chlorine in Chlorides.
Brancaster, 18 wells.	0 to ·0322	·0028 to ·0154	·06 to 6·72	Nil.	2·4 to 19·5
Dersingham, 2 wells.	·002 & ·007	·0245 & ·048	1· & 11·7	Nil and traces.	2·5 & 18·9
East Rudham, 1 well.	·0014	·0126	1·88	Nil.	1·9
Heacham, 20 wells.	0 to ·1162	·0035 to ·0437	·061 to 7·	Nil to trace.	4· to 23·8
Holme, 1 well	·0014	·0049	1·2	Nil.	6·15
Snettisham, 2 wells.	·0007 & ·0077	·0049 & ·0063	2·46 & 4·2	Nil.	7·9 & 14·7

Of course, many of these waters are described as more or less bad, notably in the case of Heacham (from the village), with 12 so-classed.

Feltwell.

Feltwell Lodge, E.N.E. of the village.

By R. Bodmer (for Clinical Research Association), March, 1901.

In grains per gallon.

Total solids, dried at 120°C.	17·5
Combined chlorine (expressed as NaCl. 1·73)	1·05
Nitrogen as nitrates (none as nitrites)	·49
Albuminoid ammonia (no saline ammonia)	·001
Oxygen absorbed in 4 hours at 27°C.	·008

No lead or copper.

Hardness 12·6°.

"A water of a very high degree of organic purity, the unoxidised organic matter being almost nil."

"Nitrates are not excessive for a chalk water and hardness is also moderate. It should be an excellent water for drinking and domestic use."

Fincham.

From Dr. R. Farrar's Report to the Local Government Board, 1906, No. 238, p. 12.

Two analyses, by the Clinical Research Association.

1. Banyard's Yard Well.

In parts per 100,000.

Total solids	63·14
Combined chlorine (expressed as NaCl. 9·9)	6·
Nitrogen as nitrates	3·
Saline ammonia	·002
Albuminoid ammonia	·083
Nitrites	Nil.
Total hardness	27·6

A decidedly polluted water, showing evidence of both recent and previous sewage-pollution.

Bacteriologic examination. Number of organisms which produce colonies on gelatine plates average 25,000 per cubic centimetre of the sample. *Bacillus coli communis* isolated from as small a quantity as one cubic centimetre of the water. Strong evidence of dangerous pollution with sewage or dejecta.

Fincham—*continued.*

2. Well in a baker's yard.

In grains per gallon.

Total solids, dried at 120°C.	105·14
Combined chlorine (as NaCl. 22·11)	13·82
Nitrogen as nitrates	4·9
„ „ nitrites	Minute trace.
Saline ammonia	·049
Albuminoid ammonia	·014
Oxygen absorbed in 4 hours at 27°C.	·07
Lead or copper	Nil.
Total hardness	43°

A highly polluted water loaded with nitrates and containing very much unoxidised organic matter. The extremely high saline ammonia points to recent sewage pollution. From the chemical point of view the water is unfit for drinking.

Gayton.

Lynn Waterworks (*see* p. 87).

By J. W. KNIGHT, January, 1913.

In grains per gallon.

Total solid matter	17·
Chlorides [? chlorine] (= sodium-chloride 2·3)	1·4
Nitrates (expressed as nitrogen)	·3
Ammonia, free	·0007
„ albuminoid	·0021
Oxygen absorbed by organic matter in 15 minutes at 140°F.	·0112
Metals	None.

Hardness, temporary 12·9°, permanent 1·1°.

Appearance in 2 feet tube, clear, pale blue.

Smell, when heated to 100°F., none.

Microscopic examination, no deposit.

Total solid matter, chlorides and nitrates low and satisfactory.

Ammonia and oxygen absorbed all very low and show an absence of organic matter.

The water is unpolluted, very pure, and fit for drinking purposes.

Halvergate.

Ordnance Map 162, new ser. (Norfolk 77).

Geologic Map 66, N.E.

From Seven Wells. Made and communicated by F. SUTTON.

Place.	Date, 1918.	Ammonia.		Chlorine.	Nitrates.	Nitrites.
		Free.	Albuminoid.			
1. Hare and Hounds (or Bradshaws)	Sept. 11	trace	·004	5·8	1·68	Nil.
	„ 28	·0007	·0126	5·9	2·24	Nil.
	Oct. 24 (1917)	·0014	·0098	8·15	3·28	Very faint trace.
2. Harpers	Sept. 11	trace	·013	5·4	2·32	Nil.
	„ 28	·0077	·0084	5·5	2·57	Faint trace.
3. Gaze's, near Post Office.	Oct. 18	·0025	·0118	8·4	1·93	Trace.
4. Harper's Cottage, S. of Church.	„ 18	trace	·008	4·3	·86	Nil.
5. Red Lion	„ 15	·004	·004	4·5	1·21	Faint trace.
6. Gillett's, 80 feet deep?	Aug. 28	·0014	·0028	3·8	·31	Nil.
7. Suttons	Oct. 18	·0028	·0014	2·3	·29	Nil.

Halvergate—*continued.*

Classification.

1, 2, 3 bad, and polluted with drainage of animal origin.

4, 5 moderately good, and probably safe.

6, 7 good, approximating in purity to the natural unpolluted water of the locality.

Bacteriologic Results.

1. 670,000 organisms per c.c. *B. coli* present in 1 c.c.

2. 32,860 „ „ „ „ ·01 „

A sketch-map shows that 1, 2, 3, 4, 6 are near the church, and 7 is but little further therefrom.

The following remarks are abbreviated from a Report by F. SUTTON :—

"I inspected the well at the Hare and Hounds . . . and also the land surrounding it."

"There is an acre of land in the village of Boulder Clay, in the shape of an hour-glass, the village being on the neck. The water obtained is from sand. The two wells (? 1 and 2) appear to be sunk to the depth of about 50 feet. The pollution is derived from animal and surface drainage in the immediate locality. I examined Mr. Gaze's well, about 100 yards from these. It is an open well, of similar character. The water is dangerous, in some respects worse than that of the other two wells. The water in these three wells is derived from the same pockets of water-yielding sand: consequently there is no flow of water."

"I examined the water of four other wells, which are sunk, not in Boulder Clay, but in the sand-area. The water in these is much better, owing, I suggest, to the free flow of water in the strata."

"Sutton's well, in the sand-area, has the best water in the village, and it is closest to the wells in question (1, 2, 3). In the opposite direction Gillett's well is the second best; it is also in sand and about 80 feet deep. Harper's Cottage well, about 100 yards from the wells in question (1, 2, 3), is also in sand, and the water is good."

"I think that if a tight tube were inserted into the deepest strata, so that the water came from a larger area, good water should be obtainable."

Harleston.

1. From "the Harleston Bore." By DR. ROBINSON.

Organic matter, about 10 grains per gallon.
Total solids, „ 80 „ „
Hardness 30°.

Bright and clear on drawing, but became turbid and deposited brown sediment on standing, giving off a sulphuretted odour.

2. From a well sunk to within about 10 feet of the chalk.

Report of the County Analyst,

Ammonia from vegetable organic matter	·004
Chlorine	3·71
Nitrogen as nitrates	·56
Lime	22·26
Magnesia	2·57
Sulphuric anhydride	6·062
Silica, oxide of iron, and alumina	·91

Total solids 43·4 grains per gallon.

"The water is entirely free from animal organic matter
mental to health in the slightest degree."

Hockham.

The Hall.

Communicated by W. L. Sutton.

A. Direct from well. B. After pumping.

In both colour almost nil, odour none, turbidity slight.

In parts per 100,000.

	A.	B.
Total solid matter	50·9	51·1
Losing on ignition	3·	2·9
Combined chlorine	3·21	3·14
Equal to common salt...	5·3	5·19
Nitrogen as nitrates	·9	·9
Nitrites	None.	None.
Saline ammonia	·004	·003
Albuminoid ammonia	·019	·017
Oxygen absorbed from permanganate (4 hours at 80°F.)	·081	·081
Zinc in solution (derived from tank or pipes)	None.	Trace.
Hardness (Clark's Scale), temporary	18·8°	18·9°
" " " permanent	4·4°	4·8°

As compared with a sample of 23rd May, a slight improvement has been effected; the turbidity has much decreased, and is due to chalk; nitrates and permanent hardness are higher. The waters remain organically impure and are not safe for drinking purposes. Efficient filtration would yield a safe, though hard, supply; but in addition the polluting matter which has access to the well must be cut off.

Hockwold

Hockwold Hall (*see* p. 94).

Made and communicated by Dr. J. C. Thresh, August 1899.

In parts per 100,000.

			Probable combinations.	
Ca.	...	11·75	Calcium carbonate	18·7
Mg.	...	·5	" sulphate	8·5
Na.	...	1·4	" nitrate	6·95
Co_3	...	11·2	Magnesium chloride	2·
SO_4	...	6·	Sodium chloride	3·5
Cl.	...	3·6	Water of hydration, etc....	3·85
NO	...	5·2		
			Total solid constituents dried at 180° C.	43·5
			Free ammonia	·002
			Organic ammonia	0·
			Oxygen absorbed in 3 hours at 37°C. ...	·0177
			Nitrites	Nil.

Hardness, temporary 20°, permanent 11°, total 31°.

Holt.

Rev. Lloyd's Borehole. *See* p. 96.

By R. A. Cripps, 1905.

In grains per gallon.

Total solids	19·
Chlorine	1·8
Ammonia	·0084
Albuminoid ammonia	absent
Nitrogen as nitrites	„
„ nitrates	„
Oxygen absorbed in five minutes	·01
„ „ three hours	·025
Lead	absent

Hardness, Clark's scale, temporary 2·5°, permanent 7·4°, total 9·9°.

Colour greenish. Odour when heated none. Microscopic examination satisfactory.

This water is of excellent quality, free from any suspicion of organic pollution and from injurious metals. It may be used for drinking purposes with confidence.

Kilverstone.

Ordnance Map 174, new ser. (Norfolk 103, N.W.).
Geologic Map 50, N.W.
The Hall.

Made (17th October, 1900) and communicated by Messrs. Sutton.

A. From pump in stable-yard. B. From spring in meadow.

In grains per gallon.

	A.	B.
Total solids in solution	21·35	18·55
Ammonia, free	Nil	Nil.
Ammonia, organic	Trace only	Trace only.
Chlorine	1·3	1·2
Nitrogen as nitrates	·49	·43
Oxygen absorbed in 4 hours	·0039	·0009
Hardness before boiling, Clark's scale ...	17·8°	11·9°
„ after „ „ ...	3·2°	2·9°

Both clear, bright, good colour, no smell.

No bacteriologic examination made, as waters of this character seldom need it.

Both free from any trace of sewage or surface-drainage contamination: practically no sign of either animal or vegetable organic matters in either. They both compare favourably in this respect with the deep chalk wells in some parts of Norfolk, and are excellent for drinking and general dietetic purposes. The hardness in A is rather high. In both it is considerably reduced by boiling.

Kirby Bedon.

(*See* p. 97.)

F. Sutton records in Trans. Norfolk Nat. Soc. 1885, vol. iv., pt. i, pp. 44–50, that in June, 1884, his attention was called "to a well newly sunk . . . the water of which showed some features rather uncommon in this district. It was alleged that the water was of much higher temperature when fresh drawn than the surrounding atmosphere; and, moreover, that it was both undrinkable, and possessed such peculiar characters in other respects, as to render it entirely unfit for general domestic use. When attempts were made to wash . . . with it, it was found that instead of tending to cleanse away dirt, quite an opposite effect was produced, and everything was stained and made more dirty. . . On attempting to use soap with it, the evil nature of the water was rendered even more apparent, for it rapidly decomposed the soap, setting free the fatty acids into a dirty greasy scum. When boiled it turned completely black."

"When first drawn from the well the water is quite clear. . . After exposure to the air for an hour or two the water becomes opaque, and deposits a bright red precipitate of oxide of iron."

The following are the analyses, in grains per gallon :—

	June, 1884.	Dec., 1884.
Oxide of iron	42·24	17·5
Lime	60·2	62·86
Magnesia	23·71	17·64
Sulphuric acid	155·68	133·7
Chlorine	29·4	27·5
Carbonic acid and alkalies, with some alumina and silica	53·2	48·8
	364·43	308·

Traces of ammonia and potash; no phosphoric acid, nitric acid, or heavy metals.

"These enormous quantities of iron, magnesia, and sulphuric acid . . are positively startling. If it had been the drainage water from an iron mine, one could understand it, but to find such a water in the heart of the Chalk district is decidedly a novelty, and moreover they are just those things which are found least in the ordinary Norfolk waters." It is to be noted, however, that the Chalk here is for the most part thickly covered with Drift and Crag, so that one would hardly take the district as a regular Chalk one.

"The origin of the iron and sulphuric acid is doubtless iron pyrites . . known to exist occasionally in the clays and marls of the district."

As to the magnesia he suggests "that there must be a boulder of dolomite or magnesian limestone in contact with the iron pyrites, or within the immediate neighbourhood. . Or . . that the well is sunk into an old sea-bed, the salts of which are largely composed of magnesia, and from some protecting cause have not been washed out of the soil. . This view is much favoured by the abnormal quantity of chlorine."

He also suggests "that this well has been sunk into a pocket or fissure, surrounded by some impermeable, or at least not easily permeable, material, such as clay, in which these concentrated chemical substances have been stored up for ages, but that the opening of this well has disturbed the strata, admitting air and water . . and hence the present state of affairs."

"The change that has already taken place between the nature of the water as first examined, and after a lapse of six months, shows that the peculiar constituents are diminishing, although I do not suppose the water has been much used."

Loddon.

From Dr. S. M. Copeman's Report to the Local Government Board, 1895. No. 95.

1. Town-pump. 2. Town-pump, second analysis. 3. Pump in Campbell's Yard.

All by Messrs. Allen and Hanbury, May, 1895.

Physical Characteristics.	1.	2.	3.
Colour when examined in a tube two feet long.	Yellowish, slightly opaque.	Yellowish, slightly opaque.	Yellowish, opaque.
Suspended matter	Faint trace	Slight trace	None.
Smell when heated to 100° F. ...	None	None	Offensive.
Taste „ „ „	None	None	—
Hardness before boiling, Clark's scale...	35°	40°	60°
„ after „ „ ...	18°	16°	28°
Chemical Results.	In grains per gallon.		
Total solid matter	80·5	79·8	111·3
Loss on ignition	18·2	11·2	14·7
Total mineral matter	62·3	68·6	96·6
Chlorine, equal to chloride of sodium	11·8	11·9	20·3
Lead, copper, iron	None	None	None.
Phosphoric acid	Trace	Trace	Heavy trace.
Nitrogen as ammonia	·0045	·0058	·004
„ „ albuminoid ammonia ...	·0051	·0078	·0127
„ „ nitrates	2·44	2·3	4·25
Oxygen absorbed by organic matter from solution of permanganate of potash at 80° F. in two minutes ...	Nil	Nil	·0056
Ditto in four hours	·0952	·126	·159

Microscopic Results.

1. 2. Fibres, spores, very little deposit.

3. Fibres, spores, vegetable debris, only a trace of deposit.

Remarks.

1. A very unsatisfactory water. Nitrates excessive and indicate previous animal contamination, probably due to polluted surface drainage leaking into the supply. Most undesirable for dietetic purposes and unfit for drinking.

2. Similar to 1. Excessively hard.

3. Very impure water. The albuminoid ammonia, nitrates, and oxygen absorbed are much in excess. Heavily polluted with sewage, and unfit for drinking.

The following two analysis were made in June, 1895, by F. Sutton (same authority):—

4. Town-pump. 5. Private supply.

	In grains per gallon.	
	4.	5.
Ammonia, free	·0035	·0021
„ organic	·0098	·0105
Chlorine	7·56	5·18
Nitrogen as nitrates	4·34	3·5

There is evidence of a large amount of pollution of a sewage nature in both waters, and they ought not to be used for drinking.

Metton.

Cromer Water Works. *See* p. 102.

A. By B. Blount, October, 1910 (sample from rising main). B, C (by same), 1913 ?

B. Unfiltered water. C. Filtered water.

	A.	B.	C.
		Grains per gallon.	
Total solids	24·08	24·36	24·08
Chlorine...	2·2	2·15	2·15
		Parts per 100,000.	
Free ammonia	·003	·007	·007
Albuminoid ammonia	Trace	Trace	Trace.
Oxygen absorbed	·01	Trace	·01
Nitrogen as nitrites	Nil	Nil	Nil.
„ „ nitrates	Nil	Nil	Nil.
Iron	·07	·13 grains per gallon.	Trace.
Hardness	14°	14·5°	14·5°

A. Free from organic impurity, but with a small quantity of iron.

B. Sample slightly cloudy and faintly coloured with iron-oxide. Taste and smell normal.

C. Clear, colourless. Taste and smell normal.

Analysis made July, 1913, at R. Inst. Public Health.

Colour in two-foot stratum, greenish-yellow, opalescent.

Suspended matters ; small quantity of vegetable and mineral matter.

Odour, when warmed at 37° C., none.

Reaction, alkaline.

	In parts per 100,000.
Total solids, dried at 100° C.	31·5
Chlorine (= 5·76 sodium-chloride)	3·5
Nitrites	Nil
Nitrogen as nitrates	Nil
Saline ammonia	·009
Albuminoid ammonia	·003
Oxygen absorbed in three hours, at 37° C.	·018
Poisonous metals (lead, copper)	Nil

Hardness, temporary 9, permanent 3, total 12.

No exception can be taken to this water on chemical grounds ; the physical characters are, however, unsatisfactory.

Mundesley.

Boring. By F. Sutton, 23rd November, 1898.

	In grains per gallon.
Free ammonia	·0084
Albuminoid ammonia	·0007
Chlorine...	3·7
Nitrogen	Nil.
Oxygen absorbed	·03
Total solids	32·5

Hardness before boiling 19°, after boiling 5·4°.

Norwich.

1. The following table of analyses of water used in Norwich in 1850 from a number of wells in (? or near) the city is taken from W. LEE's Report to the General Board of Health, 1851. It is of interest as showing the state of things that held long ago (*see* p. 45). It is needless to repeat various other particulars which are given, such as colour and taste.

The analyses were made by D. DALRYMPLE, and the figures stand for grains per gallon.

Site.	Reaction.	Common Salt.	Sulphate of lime.	Carbonate of lime.	Magnesia.	Siliceous sand.	Alumina.	Organic matter.	Waste.	Unknown.	Total.
Chapel Street, Crock's Place	Neutral	41·07	16·08	17·06	1·	1·06	—	2·01	—	—	83·08
Cock-yard, St. Paul's ...	,,	49·	12·	13·	—	—	—	4·	—	—	78·
Barleycorn Yard	,,	61·02	24·	16·	4·	2·	20·05	4·	3·	8·	124·07
Fisher's Lane	,,	22·	14·	3·02	—	2·	—	2·08	—	—	44·
Sayer's Buildings, Lower Heigham Street.	,,	84·	6·	10·	—	4·	—	None	—	—	104·
Marquis of Granby ...	Slightly alkaline.	48·	15·02	44·08	—	20·	8·	8·	—	—	144·
Butcher's Yard	Neutral	104·09	32·09	20·03	20·06	3·05	—	7·04	·04	—	172·
Lawn's Fields, Heigham ...	Slightly alkaline.	32·	8·	15·06	1·	—	2·02	3·02	—	—	62·
Lown's Yard, St. James' ...	Neutral	48·	6·	12·	—	—	—	2·	—	—	68·
Badding's Lane	,,	57·	19·06	21·04	—	—	—	4·	—	—	102·
Public Pump, Hay Hill ...	,,	53·02	18·08	14·08	·02	—	—	3·	—	—	84·

The organic matter averages 3·068 grains.

The remarkable feature in all is the great excess of common salt (average 54·063 grains), which he credits to animal exuviæ making their way into the wells from privies and drains.

The great quantity of sulphate of lime proves the water bad for dietetic, culinary, and domestic purposes. It makes bad tea and bad grog. Now with the modern supply the citizens can have their tea and grog in safety.

Norwich—*continued.*

The table on p. 159 refers to things of the long past, and the following entry giving more details, is from what may be called an old publication. We owe to W. L. Sutton five modern analyses (3–5) of Norwich well-waters, four of which are the more valuable as giving the mineral constituents in detail.

2. Two analyses. From *Rivers Poll. Comm. Sixth Report*, 1874, pp. 100 and 83.

A. Carrow Works, *see* p. 106. September 17th, 1868. Well 400 feet deep. B. In Toper Square. Shallow well in Chalk, June 18th, 1872.

In parts per 100,000.

	A.	B.
Total solid impurity	38·14	118·32
Organic carbon	·074	·102
Organic nitrogen	·027	·034
Ammonia	0	0
Nitrogen as nitrates and nitrites	1·001	5·766
Total combined nitrogen...	1·028	5·8
Previous sewage or animal contamination (*see* note, p. 146)	9,690	57,340
Chlorine	2·58	10·
Hardness, temporary	23·3	31·8
Hardness, permanent	6·4	28·7
Hardness, total	29·7	60·5

A. Clear and palatable. B. Turbid, palatable.

3. Messrs. Caley's Works (*see* p. 106). From the older well, over 400 feet deep.

Made (7th June, 1915) and communicated by Messrs. Sutton.

In grains per gallon.

Ammonia, free	·01
„ albuminoid	Nil.
Chlorine	3·1
Nitrogen as nitrates	·7
Nitrites	Nil.
Oxygen absorbed in 4 hours	Nil.
Lime	12·72
Magnesia	7·56
Soda	3·1
Sulphuric anhydride	4·13
Silica, iron and alumina	·87
Total solids in solution, probably combined as below ...	38·57
Calcium carbonate	17·57
„ sulphate	7·01
Magnesium chloride	1·78
Sodium chloride	2·92
„ nitrate	4·25
Silica, iron and alumina	·87
Water of combination and traces	4·17

Hardness before boiling 13·6°, after boiling 5·3°.

Norwich—*continued.*

4. Pockthorpe Brewery. *See* p. 109.

First two columns of figures made (1911) and communicated by F. SUTTON. The third column by L. BRIANT, December, 1908.

	May 30th.	May 10th.	Briant.
	In grains per gallon.		
Saline residue	38·59	33·54	28·96
Lime	9·71	10·36	10·35
Magnesia	1·7	·91	·86
Soda	7·08	4·54	2·81
Potash	·81	·5	trace
Sulphuric acid (SO_3)	1·66	3·36	2·55
Nitric acid (N_2O_5)	1·25	1·67	3·73
Nitrous acid	very faint trace	trace	faint trace
Chlorine	8·1	5·2	3 22
Iron	·028	112	trace
Poisonous metals probable combination	—	—	Nil
Chloride of sodium	13·35	8·57	5·31
Sulphate of lime...	2·82	5·71	4·34
Nitrate of lime	1·9	2·53	5·66
Carbonate of lime	14·11	12·76	11·84
Carbonate of magnesia	3·57	1·91	1·81
Iron, potash, water of combination, &c.	2·84	2·06	—
	In parts per million.		
Ammonia, free	·06	·036	Nil
Ammonia, albuminoid	trace	trace	·020
	In parts per 100,000.		
Oxygen required to oxidize organic matter	·0091	·007	·010

Of Briant's analysis it is said that the sample is free from all present pollution, it being bright and free from smell. The alterations in the water are very slight, but comparison with earlier analyses shows that the nitric acid has slightly but distinctly risen.

Of Sutton's analyses it is said of the earlier that "the water maintains its organic purity. It differs from the sample examined in March in giving higher figures for chlorine, but lower for nitrates, whilst the iron has increased tenfold. The chlorine is high for a deep chalk-water of the locality. The nitrate figure is satisfactory and as low as is likely to be obtained. The iron exists as carbonate, which tends to deposit a hydrated oxide on exposure to air, rendering the water opalescent or discoloured. This may be only temporary."

The later is the third sample taken. "It differs from the last mainly in showing a rise in chloride of sodium. The second sample (of May 10th) showed a rise of 2½ grains compared with the first. The common salt therefore has risen progressively. It is now high, but not too high, so long as it remains about the present figure, for drinking purposes. The nitrates show a slight decrease, and the iron and sulphate have diminished. The water remains organically good."

5. Workhouse *See* p. 110.

Made (29th May, 1901) and communicated by MESSRS. SUTTON.

Sample taken from the rising main of the well, 20th May.

In grains per gallon	
Total solids in solution	38·64
Ammonia, free	Nil.
„ organic	·0021

Norwich—*continued.*

In grains per gallon.

Chlorine		2·7
Nitrogen as nitrates		·24
Oxygen absorbed in 4 hours		·01
Lime		8·7
Magnesia		·75
Sulphuric anhydride		1·96
Organic carbon	·204	parts per
„ nitrogen	·013	million.

Hardness before boiling 13·7°, after boiling 7·5°.

Clear, brilliant, and practically colourless.

Number of microbes per c.c. 5 only. Ordinary harmless germs. No trace of any forms peculiar to sewage or any zymotic disease.

The above figures are extremely satisfactory from a chemical point of view, and the bacterial examination comes out exceptionally good for a deep well-water. The only objectionable feature is the hardness, not on account of health, but for washing or its use in steam-boilers and hot water-pipes.

Roudham.

Harling Road Aerodrome. *See* p. 112.

Communicated by the War Office, October, 1916.

In parts per 100,000.

Chlorine	2·7
Free ammonia	·005
Albuminoid ammonia	·008
Nitrogen as nitrates	·2
„ nitrites	Nil.
Poisonous metals	Nil.

Hardness: permanent 11°, temporary 25°; total 36°.

This sample is a very hard water, but otherwise it is satisfactory for domestic use.

Bacteriologic Examination.—This water grew a Coliform Bacillus, which was not typically *Bacillus coli* of Escherich, in 25 cc., but not in any less quantity. It may be regarded as a safe water for domestic and drinking purposes.

Rushall.

For military purposes. *See* p. 114.

Communicated by the Metropolitan Water Board (= T. W. Restler).

In grains per gallon.

Total dissolved solids, dried at 290°F., 35·3, made up as follows:—

Calcium carbonate	22·85
Magnesium „	1·73
„ sulphate	3·48
„ chloride	·14
Sodium „	3·42
Silica	·98
Organic matter expelled at 290°F., etc. (by difference)	2·7
Free carbonic acid	2·4

Hardness: temporary 24°, permanent 4·86°; total 28·86°.

Rushford.

Snarehill Aerodrome. *See* p. 114.

Communicated by the War Office, September, 1916.

In parts per 100,000.

Chlorine...	1·7
Free ammonia	·0006
Albuminoid ammonia	·003
Nitrogen as nitrates	·44
,, nitrites	—
Poisonous metals	Nil.

Hardness: permanent 5°, temporary 15°; total 20°.

This sample is a very pure water. The hardness, though above the average, being mainly temporary could easily be removed. It is a very satisfactory water for domestic use.

Sandringham.

Sandringham House. A set of old analyses, from *Riv. Poll. Comm. Sixth Report*, 1874, pp. 82 and 422—4.

1. Pump at stables. 2. New pump in courtyard. 3. Original pump near house. All December 10th, 1871. 12 others from tap in kitchen are given. All are from shallow wells.

In parts per 100,000.

	1.	2.	3.
Total solid impurity	29·6	46·6	37·96
Organic carbon	·043	·234	·223
Organic nitrogen	·022	·056	·068
Ammonia	·003	·018	·001
Nitrogen as nitrates and nitrites... ...	2·122	1·275	1·31
Total combined nitrogen	2·146	1·346	1·379
Previous sewage or animal contamination (*see* note, p. 146)	20,920	12,580	12,790
Chlorine	5·8	6·4	5·25
Hardness, temporary	·6	8·6	7·6
Hardness, permanent	14·3	17·1	15·4
Hardness, total	14·9	25·7	23·

1. Clear and palatable.
2. Very slightly turbid, palatable.
3. Slightly turbid, palatable.

"The condition of the Sandringham water supply at the close of the year 1871 may be gathered chiefly from an inspection of the columns . . . headed 'organic carbon,' 'organic nitrogen,' and 'previous sewage or animal contamination.' The actual condition of the waters at the time of analysis, being indicated by the two first named columns, whilst their past history is revealed in the last. The pump water from the stables contains only a very small amount of organic elements; in other words, its actual contamination is small; but on the other hand the evidence of its past pollution is very strong. . . ."

"Taking into consideration the past history of these waters, the large proportion of organic elements in the second and third samples is very ominous, and proclaims these waters to be unsafe for human consumption."

Of the samples from the tap in the kitchen (not now given) two contained large proportions of organic impurity; three contained more moderate proportions, but were suspicious; two others were much polluted; two were good; one was excellent, and one most excellent.

"The sandy soil around the House and offices obviously receives large contributions from sewers, or cesspools, and general surface soakage; it is therefore impossible to obtain from it a good and wholesome water," and, therefore, the establishment of a supply at a distance is advised.

The above abbreviated account is an interesting example of the dangers that sometimes arise in the water-supply of a large house, in this case of course one of great importance. A new supply has of course been got. (*See* p. 116.)

Sheringham.

1. Water Co. Mixed supply, well and spring. *See* p. 117.

Communicated by the Local Government Board.

A. By F. Sutton, Feb., 1911. B. By W. L. Sutton, Jan., 1914.

In grains per gallon.

	A.	B.
Total solids in solution	39·	35·14
Ammonia, free	Nil.	Nil.
„ albuminoid...	·002	Faint trace.
Chlorine...	5·	5·21
Nitrogen as nitrates	·27	·41
Nitrites	Nil.	Nil.
Oxygen absorbed in four hours	·05	·023
Hardness, before boiling	19·57	20·
„ after „	8·28	7·85

Both, bright and clear.

Another analysis, of Nov., 1912, gives ·28 of nitrogen as nitrates and 3·6 of chlorine in chlorides.

Bacteriologic Examination.—A. Number of Bacteria per cubic centimetre 200, 25 *p.c.* of which were liquefying organisms. In B. 80. In both *Bacillus coli* absent in 50 cc.

Remarks.—A. No exception can be taken on chemical grounds. Of good organic purity and free from evidence of pollution. Bacteriologically it has the character of a water exposed to surface-influence. Under present conditions (1911) the water cannot be expected to give very good bacteriologic results, but it is free from dangerous organisms. It is fit for all the purposes of a public supply.

B. Of great organic purity and of excellent quality for drinking and general domestic purposes. Satisfactory both chemically and bacteriologically.

2. From a well recently sunk by H. S. Welchman.

From P. M. Crosthwaite's Report to the Local Government Board (not printed), July, 1909.

In grains per gallon.

Free ammonia	·009
Albuminoid ammonia	·016
Nitrogen as nitrites and nitrates	Nil.
Chlorides	9·7

Slightly turbid.

"This water is contaminated with bad drainage and the soil has apparently no purifying power." Not satisfactory for drinking unless boiled.

Swanington.

? Public Supply. *See* p. 123.

By F. Sutton, April, 1896.

In grains per gallon.

Ammonia, free	·0014
„ organic	·0007
Chlorine...	1·5
Nitrogen as nitrates	None.
Oxygen required	·025
Oxide of iron	·004

This water contained in suspension some chalk obtained with oxide of iron; this settled, leaving the water clear, and in this state it contained only a mere trace of iron.

There is no trace of sewage or drainage contamination, and it evidently comes from a deep spring.

Taverham.

Times Paper Mill. *See* p. 123.

Rivers Poll. Comm. Sixth Rept., 1874, p. 100.

In parts per 100,000.

Total solid impurity	27·30
Organic carbon...	·059
Organic nitrogen	·024
Ammonia	·0
Nitrogen as nitrates and nitrites	·428
Total combined nitrogen	·452
Previous sewage or animal contamination (*see* note, p. 146)	3,960
Chlorine...	2·73
Hardness, temporary	14·4
„ permanent	5·1
„ total...	19·5

Clear and palatable.

Thetford.

1. In the Sixth Report of the Rivers Pollution Comm., 1874, p. 403, it is said that from analyses of water from some of the wells it was "found that only one was fit for human consumption . . from the pump at the Railway Hotel which contained but mere traces of organic matter. . The other well waters had been very heavily contaminated with sewage or soakage from cesspits." Analyses of five such are given on p. 84, with "total solid impurity" varying from 105·68 to 51·8 parts per 100,000. That from the Railway Hotel (7th February, 1871) was as follows :—

In parts per 100,000.

Total solid impurity	33·52
Organic carbon...	·037
Organic nitrogen	·014
Ammonia	·001
Nitrogen as nitrates and nitrites	·825
Total combined nitrogen	·84
Previous sewage or animal contamination (*see* note, p. 146)	7,920
Chlorine...	1·79
Hardness, temporary	18·3
„ permanent	5·6
„ total...	23·9

2. Waterworks. *See* p. 124.

A. By F. Sutton and Son, March, 1909. B. By the same, April, 1911. C. By W. L. Sutton (? 1912). D. By the same, May, 1913.

In grains per gallon.

	A.	B.	C.	D.
Total solids in solution ...	21·7	23·	22·6	20·
Free ammonia	·001	Nil.	Nil.	Nil.
Albuminoid ammonia ...	·0006	Nil.	Nil.	Nil.
Chlorine	1·2	1·05	1·1	1·05
Nitrogen as nitrates ...	·31	·456	·476	·476
Nitrites	Nil.	Nil.	Nil.	Nil.
Oxygen absorbed in four hours	·02	Nil.	Nil.	·0028
Hardness, before boiling ...	14·	14·	14·	13·5
„ after „ ...	4·	4·57	3·	2·8

All clear and bright.

Thetford—*continued.*

Bacteriologic Examination.—

A. Number of Bacteria per c.c. 12. No trace of *Bacillus coli* in 36 c.c.

B. No organisms found in ½ c.c., therefore practically sterile. *Bacillus coli* and allied organisms absent in 50 c.c. (as also in the other two).

C. Number of Bacteria per cubic centimetre 6. In D. 10.

B. This water is of exceptional organic purity, devoid of organic matter. Bacteriologically practically sterile. The amount of chlorine and the hardness are normal to the district. Of admirable quality for all the purposes of a public supply.

C. Practically no change compared with the analysis of about a year before.

D. No material change compared with the analysis of the year before.

The water is said to act slightly on lead! But no lead pipes are used.

3. Bidwell and Son's Brewery.

By F. Sutton, 7th December, 1901. Communicated by W. L. Sutton.

In grains per gallon.

Total solids in solution	22·4
Ammonia, free	Nil.
Ammonia, organic	Nil.
Chlorine	1·4
Nitrogen as nitrates	·18
Oxygen absorbed in 4 hours	·049
Lime	9·8
Magnesia	·2
Sulphuric anhydride	·38
Silica	1·12
Oxide of iron	·28

Hardness before boiling 17·5°, after boiling 4·5°.

Brilliantly clear, and colour excellent.

5 microbes per c.c., all harmless. No trace of sewage—or drainage—microbes.

"This water is of especially pure quality. There is not a trace of organic matter of vegetable or animal origin: it is exactly suited to the manufacture of beer and healthy mineral waters."

Trimingham.

Shallow well, 202 feet above Ordnance Datum. *See* p. 126.

By the Clinical Research Association, May, 1908.

In grains per gallon.

Combined chlorine (expressed as NaCl. 10·56)	6·4
Nitrogen as nitrates	·39
„ nitrites	Nil.
Saline ammonia	·0015
Albuminoid ammonia	·011
Oxygen absorbed in four hours at 27°C.	·081
Lead or copper	Nil.

"In its present condition this water is not a good one for drinking, as it contains much unoxidised organic matter. As it is however from a newly made well it is probable that the water may have been temporarily polluted."—R. Bodmer.

Trowse.

Well made in 1885. *See* p. 126.

Communicated by the Rev. J. Gunn.

A tepid water, analysed by F. Sutton, who says that it contains 20 per cent. [presumably meaning of the total solids] of

Trowse—*continued.*

magnesia, and suggests the presence of a boulder of magnesian limestone. The stain of the water is so adhesive that it can scarcely be taken off the hands by soap. The absence of chalk is striking.

The water contains, according to F. SUTTON :—

Protocarbonate of iron, large amount.
Sulphate of iron, in small quantity.
„ lime, very large amount.
„ magnesia, „ „ „

Walsham, North.

Waterworks. *See* p. 127.

1. By MESSRS. W. H. STANGER and B. BLOUNT. July, 1901.

Water clear and free from objectionable taste and smell.

	Grains per gallon. 1.	2.
Total solids	20·86	20·86
Chlorine...	2·45	2·1
	Parts per 100,000.	
Free ammonia	·002	Nil.
Albuminoid ammonia	·008	·0014
Oxygen absorbed after four hours	·03	·021
Nitrogen as nitrites	Nil	Nil.
„ nitrates	Nil	Nil.

Hardness 11°.

The sample free from organic contamination. Water suitable for drinking and domestic purposes.
The special mineral characteristic is iron.

2. One of three analyses by SIR W. CROOKES, June, 1902. The others are much the same. Slightly cloudy.

Wells.

G. W. WIGNER. The Water Supply of Sea-side Watering-places, 1878, pp. 3–5.

Had "no public water supply, but only a large number of wells, the water being drawn from them in most cases by pumps, one of which frequently supplies several houses. The wells are all very shallow, some only 6 feet from the surface, and probably few reach as much as 20 feet."

A. From a pump which supplied houses. B. From a pump at one of the largest hotels.

In grains per gallon.	A.	B.
Total solid matter	85·2	49·7
Loss on ignition, after deducting combined carbonic acid	13·9	11·54
Lead and copper	none	none
Iron	slight trace	slight trace
Chlorine, calculated as chlor de of sodium ...	17·73	7·37
Nitrogen, as ammonia	·0044	·0026
„ albuminoid ammonia	·0082	·0036
„ nitrates	2·6152	1·4094
„ nitrites	·0086	·0058
Total nitrogen in the four forms	2·6364	1·4214
Hardness, before boiling, Clark's scale	36°	24°
„ after „ „	31°	15°

Wells—*continued.*

A. Pumped from a well said to be under 20 feet deep. Colour of the water "yellowish green, owing to the presence of a large quantity of suspended matter." Microscopic examination "far from satisfactory, and although no living organisms could be detected, there were quite sufficient remains of organic matter to render it probable that the water had been heavily contaminated at some recent period . . there is no doubt, viewing all the details of the analysis, that the water must be condemned as totally unfit for domestic use."

C. "The water was free from suspended matter, and when viewed in a column 2 feet long it had a pale yellow tint." Microscopic appearance, "certain small particles of vegetable tissue present, but no animal matter could be detected." This sample may be passed as fairly satisfactory.

Whitlingham.

Well belonging to the Corporation of Norwich. *See* p. 130.

By W. L. Sutton, March, 1911.

Bright and clear.

In grains per gallon.

Free ammonia	Nil
Albuminoid ammonia	·0007
Nitrogen in nitrates...	1·96
Nitrites	Nil
Chlorine in chlorides	5·

The water is of great organic purity. The chlorides and nitrates are high, but there is no evidence of direct sewage pollution. It is fit for drinking purposes.

Wootton, South.

Rectory, new well. *See* p. 132.

? By F. Sutton, February, 1905.

In grains per gallon.

Free ammonia	·168
Albuminoid ammonia	·063
Nitrogen in nitrates or nitrites	Nil
Chlorine of chlorides	3·
Poisonous metals	Nil

Brown turbid colour. Smells strongly of creosote or tar. This water is bad and undrinkable. The pollution seems to be from surface-drainage. The organic impurity is very high.

Yarmouth.

Two analyses by Dr. Letheby, in 1868, quoted in G. W. Wigner's Water Supply of Sea-side Watering-places, 1878, pp. 5, 6.

1. Dene Well. 2. Church Pump.

? In grains per gallon.

	1.	2.
Carbonate of lime and magnesia	23·6	21·65
Sulphate of lime and magnesia	20·34	17·43
Alkaline chlorides	30·	12·41
„ nitrates	8·8	3·03
Silica and alumina	1·04	·64
Organic matter	1·86	1·59
	85·64	56·75

Wigner's own analyses (pp. 7, 8) are as follow :—

1. From a pump, said to be the Dene Well pump. 2. From the Church pump.

In grains per gallon.

	1.	2.
Total solid matter	112·1	75·6
Loss on ignition, after deducting combined carbonic acid	18·82	17·3
Lead and copper	None	Trace
Iron	Trace	Heavy trace
Chlorine, calculated as chloride of sodium (in 1)...	41·07	15·91
Nitrogen as ammonia	·0275	·0012
„ „ albuminoid ammonia	·0119	·0108
„ „ nitrates	4·1978	1·3491
„ „ nitrites	·0089	·0079
Total nitrogen in these four forms	4·2461	1·369
Oxygen absorbed by organic matter from a standard solution of permanganate of potash	·092	·126
Hardness, Clark's scale, before boiling	34°	30·6°
„ „ „ after „	32·6°	29°

1. Entirely differs from Letheby's analysis. Much more solid matter, chlorides and nitrates than in the latter.

Colour in 2-feet tube, pale urine-yellow. Offensive smell and taste. Heavy traces of suspended matter.

Microscopic examination "unsatisfactory, showing the presence of a large number of crystals of urate of ammonia and urate of soda, together with well-defined pieces of animal tissue of different kinds. This water is evidently quite unfit for domestic use."

2. Colour a strong urine-yellow. When warmed smell and taste most offensive. Traces of suspended matter.

Microscopic examination. Results "as bad as they could be, the sedimentary matter being full of animal fibres, and containing also living organisms."

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